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[COMMITTEE PRINT]

SCIENCE POLICY
A WORKING GLOSSARY

[THIRD EDITION—1976]

PREPARED FOR THE

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-FOURTH CONGRESS
SECOND SESSION

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LETTER OF TRANSMITTAL

House of Representatives,
Committee on Science and Technology,
Washington, D.C., January 12, 1976.

Hon. Olin E. Teague,
Chairman, Committee on Science and Technology,
House of Representatives, Washington, D.C.

Dear Mr. Chairman: I am transmitting herewith a revised edition of "Science Policy—A Working Glossary." The glossary was originally printed in April 1972, and first revised in 1973.

In this third edition, 22 new definitions have been added and 11 other definitions have been substantially amended; 32 new entries have been added in the appendix containing the annotated list of acronyms and abbreviations of organizations frequently appearing in the science policy literature, plus a new selected list of abbreviations of 26 scientific and technical societies; and two new appendices—a chronology of Federal executive branch science organization: 1787–1975 and a selected bibliography of glossaries and related sources of science and science policy terms—have also been added.

I commend this document to you and am sure that all members of the committee will find it useful.

Sincerely yours,

James W. Symington,
Chairman, Subcommittee on Science, Research and Technology.

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LETTER OF SUBMITTAL

THE LIBRARY OF CONGRESS,
CONGRESSIONAL RESEARCH SERVICE,
Washington, D.C., December 22, 1975.

Hon. JAMES W. SYMINGTON,
Chairman, Subcommittee on Science, Research, and Technology, Committee on Science and Technology, U.S. House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am pleased to submit this third edition of the glossary for science policy in response to your request. We have entitled the paper a "working glossary" in recognition of the fact that the terminology in this field is changing dynamically. Many definitions in the two revisions have been modified and new terms have been added.

The glossary was prepared initially under the direction of Dr. Franklin P. Huddle of the Science Policy Research Divison. This third edition was prepared under the direction of William C. Boesman, assisted by Dorothy M. Bates, Paul F. Rothberg, and Elaine B. Carlson of that Division.

It is suggested that correspondence recommending amplification or correction of the glossary be addressed to Dr. Huddle so that we can continue to consolidate the comments and, if you judge it desirable, update the work from time to time.

Sincerely,

NORMAN BECKHAM,
Acting Director, Congressional Research Service, Library of Congress.

SCIENCE POLICY: A WORKING GLOSSARY

CONTENTS

SCIENCE POLICY: A WORKING GLOSSARY

Introduction

The purpose of this Glossary is to facilitate communication between the Congress and persons engaged in the study of science policy. Some of the terms taken up here are used in various contexts to mean widely different things; writers in different countries or in different disciplines sometimes use different words for the same subject. There are socially important distinctions between such terms as, for example, Cost/Benefit Analysis and Risk/Benefit Analysis. The word Model has a different meaning in the expression Model Statute or Late Model Television Set from its meaning in the Forrester Dynamic Model of World Interactions.

Whether in congressional hearings, agency reports, professional symposia, or elsewhere, it is useful that the terms expressed in the discussion of issues of science policy communicate meaning according to generally accepted standards.

Debate over the meanings of words is usually fruitless. It recalls the classic example cited by S. I. Hayakawa of the two families which ceased speaking to each other over the issue of whether unemployment benefits *were* insurance payments or *were merely called* insurance payments.

Given a set of usable standard definitions, the analysis can proceed to substantive issues. The definitions presented in the following pages will not accord with the usage of all students of science policy. However, the definitions are available to be cited, or to help clarify alternative meanings.

The point is that science policy is a lively art, a field of study undergoing rapid development. Its flexibility of language reflects this tendency toward change. The standard meanings proposed in the Glossary can at least serve as peg points, useful to characterize the present State of the Art, and perhaps later on to measure how far the changes have gone when the Glossary is reviewed in a year or two hence.

It is also important to identify meanings covered by several significantly different words—reflecting different disciplines or different contexts—and to discuss these. Every scientific discipline tends to develop its own special vocabulary. When practitioners of the different disciplines come together to consider mutual problems of science policy, they bring into use their own special languages. One man's "Homeostasis" is another man's "Steady State." Analogies like these are rarely precise, but they do enable interdisciplinary communication when their degree of interchangeability is mutually understood.

The Rise of Science Policy

Since 1950, national policy in the United States has been to support scientific research as a beneficial activity for public purposes. The

assumption on which this policy is based is that the discovery and disclosure by scientists of the facts of nature broaden the options available for the application of technology to achieve public purposes. As more facts become known, their technological application enables man to improve or restore his environment, and thus to enhance the compatibility of man's relationship with the environment.

As resources of the public have been increasingly applied for this purpose, the powerful effects of the policy have become evident. These effects have become a major consideration of national policy. Intended results of scientific discovery have been achieved in countless directions. But not all aspects of the man/environment relationship have been equally well served. There have been technological lags, the march to obsolescence of entrenched technologies, and the appearance of technologies clearly dysfunctional in their intended purposes. Moreover, the effects of any given technology are invariably mixed, with some benefits accompanied by some economic, social, or physical environmental costs. The growing power of technology operates to increase the magnitude of both benefits and costs.

The formulation and implementation of national science policy involves management of the resources employed in the discovery and use of scientific information to enhance man's compatibility with his environment, and the use of the innovations that emerge from this process to produce maximum social benefits at minimum social costs. The problem of translating this twofold proposition into operational policies and procedures, and of designing institutional arrangements to implement them, turns out to be enormously complex. This is the problem of science policy. The problem is of interest not only to scientists but to political decisionmakers and the general public. If the issues of science policy must be discussed in scientific or technical terms, then it becomes important that these terms are carefully defined in language meaningful to the public.

Scope and Limitations of the Glossary

The title "A Working Glossary * * *" was selected to reflect not only the purpose of the collection but also its limitations. It is manifestly not the last word on the subject. It is open to correction or amplification. Suggestions received while the Glossary was in preparation generally have been incorporated in it; if these involved adding a new and conflicting definition, this was done. However, the register is not closed but will be open for the further posting of corrections and amplification.

Not all words selected for treatment are of equal currency. The selection was perforce arbitrary. Some inclusions may have been unnecessary; some omissions unfortunate. More terms were suggested for definition than could be included, but no decision on such matters should be regarded as final in a "Working Glossary."

A word of explanation may be helpful as to the criteria used in the selection of terms to be included in the Glossary. One of the most important of these was the assignment—for science policy purposes—of a special meaning to a term in wide general usage. Another was the existence of controversy as to which of several meanings of a policy term was the precise one. A third was the observation that change was taking place in the meaning of a policy word in frequent usage.

A few terms have been added that characterize institutional developments involving technology (e.g., Agri-business, Multinational Corporation). Also, a number of terms are included that refer to emerging technologies of potential political importance (Cable Television, Magnetohydrodynamics) or to areas of technology that might warrant legislative attention (Catalysis, Corrosion, Tribology).

Considerable correspondence was received by CRS in comment on the first issuance of the Glossary. Many suggestions were offered for additional terms to be included. The procedure followed was to attempt a Trade-off (q.v.) between satisfying all critics and applying the indicated criteria. If the result does not constitute an optimization, at least—hopefully—it will "Satisfice."

There is always a tendency to approach the subject of definition from a context which makes difficult the exclusion of the author's bias. In the study *Technical Information for Congress*, the observation was made that no person is free of bias. In defining terms, bias is virtually unavoidable. One way to try to escape it is by offering as little information as possible under each term—in effect, striving for the least common denominator. This reduces bias at the cost of reducing information content. Another approach was attempted here: a preliminary draft was submitted to more than a hundred persons engaged in science policy studies, inviting them to review it, and suggest changes or alternative wordings, to help active balanced treatments. Their help is gratefully acknowledged. If bias still remains, the fault is the author's but the remedy remains open: the identification by correspondence of opportunities for further refinement.

It was presumed that for items on which no comments were received the definitions were free of bias or else represented a consensual bias of those consulted. In the latter case, it is hoped that the wider dissemination of the Glossary will stimulate a further response and yield further emendation toward objectivity and balance.

Additional Comment on the Revised Editions

Many helpful comments have been received by the Science Policy Research Division in response to the first and second publication of the Glossary. These have been considered in preparing the present revision. The original compilation of definitions was largely the work of Dr. Franklin P. Huddle. Mr. William C. Boesman and other members of the Science Policy Research Division contributed additional definitions for the revised editions. An appendix by Mrs. Dorothy M. Bates provides a chronology of Federal executive branch science organizations 1787–1975. An appendix by Mr. Paul F. Rothberg and Mrs. Elaine B. Carlson presents a selected list of acronyms and abbreviations frequently encountered in science policy literature. The third appendix contains a selected bibliography of glossaries and related sources of science and science policy terms.

DEFINITIONS

Adaptation

A structural or functional (behavioral) modification of a system, usually self-directed, in response to a change in the external stresses operating on the system.

Adversary Process

A debate, legal contest, or other confrontation, in which decision is obtained or sought by the verbal interchanges of proponents of opposing positions in the presence of a neutral decisionmaker.

Agribusiness

The business of agriculture, as opposed to its science or practice. The essence of agribusiness is that it is capital-intensive. Productivity per man-hour is enormous; productivity per acre is not very impressive, although it is subject to constant improvement. Extensive use is made of energy materials (fertilizers, powered equipment, and aircraft). Farm units are very large. Management is often corporate, rather than family. It may consist of the initial development of agricultural land through the distribution of agricultural products in retail trade. Agribusiness may require knowledge of:

- Land surveys and purchases;
- Development of irrigation systems;
- Use of chemical fertilizers;
- Governmental development of agricultural infrastructure, like roads, water and sewerage systems, and rural electrification;
- Establishment or use of transportation systems for agricultural products;
- Establishment or use of governmental and/or private financial structures, like grant systems, agricultural or export credit institutions, and loan guarantee programs;
- Establishment or use of distribution systems, like production or retail cooperatives, farmers' markets, and elevators and storage facilities;
- General business skills, like marketing, office management, bookkeeping, and legal services; and
- Government assistance programs, like the Department of Agriculture's Extension Service, Farmers Home Administration, Banks for Cooperatives, and Community Services Administration rural development programs.

Agro-Industrial Complex

A nucleus of complementary industrial and agricultural enterprises structured around a source of cheap, abundant energy, like nuclear energy. An agro-industrial complex combines the ideas of synergism and economy of scale and might consist of:

A nuclear power station of 1,000 to 2,000 megawatts;

A plant to desalinate sea water at a rate of 1.3 to 3.8 million cubic meters per day;

A cultivable area of several thousand hectares capable of feeding several million persons on the basis of 2,500 calories per person per day; and

A certain number of industrial plants producing nitrate and phosphate fertilizers, aluminum, caustic soda, chlorine, and other products.

Agro-industrial complexes might have their greatest use in undeveloped regions, particularly desert regions near the sea.

Algorithm

A symbolic or quantitative expression of a relationship between or among different elements; a set of stepwise directions for attacking a problem. More generally, a complete system of numbers, including zero.

Alternative(s)

See Option(s). One of several possible courses of action, expedients, methods, or contrivances considered to offer the same approximate outcome or effect.

Ambience (noun)

The surroundings or environment of a place or thing. Used in experimental research to indicate, e.g., the temperature, humidity, pressure, gases, and radiation in the space surrounding the object of an experiment. (See Background.)

Ambient (adjective)

Completely surrounding.

Analysis

The action of taking something apart and examining its components. The very extent of the use of the term may seem to deprive the word of much of its meaning. It is employed in a great many different senses, and in many combinations. The meaning seems to depend somewhat on the discipline connected with its use. Thus, the chemist makes an Analysis when he discovers the quantity and quality of ingredients in something. The biologist and botanist use Analysis to signify the operation of classifying a specimen. The psychiatrist uses it to mean the treatment or cure of aberrant psychic behavior. The physician interprets the word in terms of what happens in the laboratory of pathology. The mathematician uses it in a variety of ways, for example:

(1) as a technique of proving a theorem by assuming the truth of the theorem and then searching out the consequences; (2) since integral and differential calculus are commonly used in searching out these consequences, he tends to regard any application of calculus as a form of analysis; (3) still more loosely, he regards any problem amenable to mathematical solution as "subject to analysis;" and most loosely of all, (4) analysis becomes the establishment of—or search for—any kind of quantitative relationship.

The notion that *analysis* is an identifiable and describable process independent of the discipline involved or the item being analyzed is suggested by the large number of compound words hyphenated with it. For example:

Value-
Failure-
Cost-effectiveness-
Operations-
Systems-
Stress-
Reliability-
Maintainability-
Etc.

According to Merriam-Webster the word means to "resolve into its elements." (Separation of "anything, whether an object of the senses or of the intellect, into constituent parts or elements.") Also, any statement or table exhibiting the results is "an analysis." The verb *to analyze* has as synonyms the following: *separation*, *resolution*, *dissection*, *reduction*.

There is a tendency to expand the scope of Analysis to qualitative as well as quantitative factors (see Policy Analysis). In this sense, Analysis can be qualitative if it retains such other characteristics as order and logic, explicitness or replicability, definable scope and internal consistency.

Applied Research

See Research, Applied.

Armed Services Procurement Regulation (ASPR)

The Armed Services Procurement Regulation establishes uniform policies and procedures relating to the procurement by the Department of Defense of supplies and services pursuant to the authority of 10 U.S. Code, Chapter 137 or other statutory authority.

ASPR 15, for example, deals with contract cost principles and procedures, and ASPR 15–205.35 specifically deals with independent research and development costs of particular interest to commercial organizations engaged in, and requiring support for, basic research, applied research, and development.

A contractor's independent research and development (IR&D) effort is defined in ASPR 15–205.35 as:

> that technical effort which is not sponsored by, or required in performance of, a contract or grant and which consists of projects falling within the following three areas: basic and applied research; development; and systems and other con-

cept formulation studies. IR&D effort shall not include technical effort expended in the development and preparation of technical data specifically to support the submission of a bid or proposal.

See also Procurement.

Background

Phenomena forming the natural Ambience (q.v.) of experimental research or ordinary situations. For example, the noise of natural electromagnetic radiation from solar activity is received on radio receiving sets as background, and naturally occurring terrestrial radioactivity is detected as background radiation on geiger counters set to detect large deposits of radioactive materials.

Toxic materials like mercury and arsenic may form part of the naturally occurring chemical background of the human environment. Chemical pollution from factory effluents, chemical fertilizer runoffs, and defoliants would add to this background toxicity.

In general, the background of any social, economic, environmental, political, psychological, scientific, or technological situation includes those phenomena which would distort the understanding or evaluation of the experimental or experiental situation unless the phenomena were known and accounted for in the experiment or experience. They are the situational elements in relation to which a particular vector under consideration is to be evaluated or measured. Before this evaluation or measurement can be made, the background must first be determined.

Backlash

A countervailing movement in response to, and in the opposite direction from, some specific social or technological trend.

Baseline

A standard. A reference point on some significant parameter against which changes over time can be measured. E.g., analysis of the solute content in a particular stream on a specific day of the year, so that by measuring it on the same day in subsequent years a trend can be established.

Basic Research

See Research, Basic.

Benefit/Cost Analysis

See Cost/Benefit Analysis.

Benefit/Risk Analysis

See Risk/Benefit Analysis.

Bioconversion

A biological process in which one form of energy is converted into another form of energy by plants or microorganisms, for example, by photosynthesis or bacterial digestion of sewerage sludge.

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Biomass

Broadly, the quantity of vegetable matter. However, the term is not precise: thus, Odum equates Biomass with "living weight"[1] while the McGraw-Hill *Encyclopedia of Science and Technology* defines it as the *dry* weight of living matter, including stored food, present in a species population and expressed in terms of a given area or volume of the habitat.

Biomass is a possible source of energy for industrial and residential use. Technically feasible processes to generate fuels from biomass include fermentation to produce methane and alcohol, chemical processes to produce methanol, and pyrolysis to convert waste to low Btu gaseous fuels and oils.

Brain Drain

This term is often used to refer to the movement of persons with scientific or technological knowledge, skills, or experience from one country (or State or locality) to another. The attraction of the destination can be relative—a competition among countries or localities to retain scholars; it can be political—the effect of extending or denying political or intellectual freedom to scientists; it can be the result of comparative economic opportunity—as in a rich versus a poor country; there are many other possible causes. A related expression, "Reverse Brain Drain," has been used to refer to the outflow of scientists and technologists from a country that had previously attracted them.[2]

Brainstorm (verb)

To engage in the process of Brainstorming (q.v.).

Brainstorming (noun)

Loosely, any unstructured analysis of a problem or issue. Originally a procedure designed by Osborn, it is now defined in Webster's Third New International Dictionary as follows:

To practice a conference technique by which a group attempts to find a solution for a specific problem by amassing all the ideas spontaneously contributed by its members.

Osborn sets forth the four basics of brainstorming as:

> Criticism is ruled out. Adverse judgments of ideas must be withheld until later. (This is the deferment-of-judgment principle.)
>
> "Free-wheeling" is welcomed. The wilder the idea, the better. It is easier to tame down than to think up.
>
> Quantity is wanted. The greater the number of ideas, the more the likelihood of useful ideas.

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[1] Odum, Eugene P., *Fundamentals of Ecology*, third edition (Philadelphia: W. B. Saunders Company, 1971), p. 8.

[2] See U.S. Congress. House, Committee on Foreign Affairs, Subcommittee on National Security Policy and Scientific Developments, *Science, Technology, and American Diplomacy: Brain Drain: A Study of the Persistent Issue on International Scientific Mobility*, 93d Congress, 2d Session. (Washington, D.C.: U.S. Government Printing Office, 1974), 272 p. [Committee Print.]

Combination and improvement are sought. In addition to contributing ideas of their own, participants should suggest how others can be turned into better ideas, or how two or more ideas can be joined into still another idea.[3]

Cable Television (CATV)

A system of receiving, transmitting, and more recently originating (cablecasting) television signals for the use of system subscriber (generally households). CATV generally transmits, by coaxial cable, signals from local television (and perhaps radio) stations and stations in distant cities, according to the "carriage" rules of the Federal Communications Commission (F.C.C.). In addition to commercial broadcast stations, CATV may carry programs of local public interest and government proceedings on closed circuit channels, and may be required to provide a cablecasting channel and public access channels for local expression. CATV may also provide closed circuit channels to local school systems and to municipal service organizations, like police and fire departments.

Most recently installed CATV systems provide 12 channels, with 20 or 40 channels likely to become common. The broadcasting industry has also proposed the extensive development of two-way (duplex) CATV systems enabling subscribers to initiate communications with stores, banks, and opinion and voting polls. The comprehensive, two-way use of cable systems for such numerous services has been called the "wired-city concept."

At present, CATV is largely a system for television entertainment; it generally costs subscribers from $5 to $15 per month, plus small installation charges. Its development in the major television markets has been somewhat restricted by F.C.C. rules governing the carriage of broadcast signals.

Initially, CATV was thought to affect adversely the development of UHF stations. To the contrary, some studies subsequently indicated that CATV extends the markets of the, generally, weaker UHF stations.

CATV also has implications for pay television (PTV). Opponents of PTV claim that CATV is the first step toward PTV which, it is also claimed, will damage "free" commercial TV.

Catalysis

Catalysis is a mechanism by which the rate of a chemical reaction is increased by some particular mediating substance, called a "catalyst," which remains in its initial form when the reaction is completed. The catalyst allows the starting substances of a chemical process to react to form the products of the reaction at a faster rate than when the catalyst is absent. Catalysis as an important technology offers opportunities to improve environmental quality using such devices as Catalytic Converters (q.v.) attached to automobile exhausts, to increase

[3] Alex F. Osborn, *Applied Imagination: Principles and Procedures of Creative Problem-Solving*, third revised edition (New York: Charles Scribner's Sons, 1963), p. 156.

energy supplies using fuel cells and coal gasification, and to enhance industrial productivity with improved and new catalytic reactions for industrial applications.

In common usage, the word "catalyst" refers to any element in a situation that facilitates change. For instance, in the United States, public opinion can serve as the catalyst to motivate the Congress to institute a new law or to change an existing law.

Catalytic Converter

The catalytic converter (also called "dual catalytic converter") is a device designed to receive exhaust gases from automobile exhausts and promote chemical reactions to reduce levels of undesired pollutants released. Remaining hydrocarbons and carbon monoxide are burned and NO_x (oxides of nitrogen) is disassociated (broken down into oxygen and nitrogen) by these devices.

The first portion of the system in widest use is a NO_x catalyst converter. As the exhaust gas flows through the converter, the NO_x is broken down into nitrogen and oxygen by a catalyst in the form of a coating on a honeycomb matrix or on small diameter pellets in the converter. The partly cleaned exhaust then passes through a second converter system, in which hydrocarbons are converted into carbon dioxide and water, and carbon monoxide is converted into carbon dioxide. The exhaust gas emerges from the back of the second converter and passes through the conventional muffler.[4] About 85 percent of 1975 U.S. automobiles were equipped with catalytic converters to meet current standards.

CATV

See Cable Television.

Citation Analysis

Citation analysis is an evaluation technique to measure how technical information is transferred among scientific and other professional authors. The concept is that by counting and indexing the footnoted references of published papers, a measure can be developed of papers most often used by other scholars. The higher ranking a paper receives in the citation index, therefore, the greater value is hypothetically assigned to it as a source of ideas.

Citation indexes for scientific literature are available through several commercial groups, one of which is the Institute for Scientific Information (ISI) in Philadelphia. ISI first published the Science Citation Index (SCI) in 1963, and began a Social Sciences Citation Index (SSCI) several years later. Citation indexes are also available for law reviews and periodicals for legal articles.

As stated by Melvin Weinstock of ISI:

> Citation indexing is based on the simple concept that an author's references to previously recorded information identify much of the earlier work that is pertinent to the subject of his present document.

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[4] Crouse, William H., *Automobile Emission Control* (New York, McGraw-Hill Book Company, 1971), 136 p.

Proponents of citation analysis view this technique as a possibly useful tool in judging the value of proposed research projects or in assessing the impact of federally funded research and development.

Citizen Participation

Involvement of the public in decisionmaking. At least three different forms of such an involvement can be distinguished: (1) participation in the selection of the decisionmakers, i.e., exercise of the right to vote; (2) involvement in the deliberations of the decisionmakers by communications and representations of interest in a desired outcome, or as to the methodology to be employed in the making of the decisions; and (3) public participation in the decision itself (sometimes called "direct democracy") plebiscite, public convention, or other means.

Closed Cycle

A concept involving a flow of material through a system that does not discharge wastes but returns the flow to become input into the system. It is a hypothetical concept, as loss is probably unavoidable in even the most carefully designed and managed system. However, it is to be distinguished from energy cycles, in which the second law of thermodynamics applies, and in which the loss through entropy is generally calculable. Compare Materials Cycle.

Communication(s) (and Communication Theory)

Communication is an essential element of all systems. In simplest form a communication is any transmission of meaning, by signs, signals, or symbols, between persons or stations. Communication takes many forms and employs many media.

Communication theory (cybernetics) concerns the relationship between communication and control. It refers specifically to the regulative processes of physical, biological, and behavioral systems, with a special emphasis on Feedback (q.v.). Feedback, which tells the system how to adapt itself to changing situations, enables control of a system on the basis of actual performance rather than expected performance. Negative feedback reverses the direction of the main system; positive feedback amplifies or intensifies the work of the main system.

Information theory is another complex aspect of communication theory. It proposes to measure the effect of operations by which a particular selection is made from a range of possibilities. It is related to probability theory in that the measure of selectivity is a function of the probability of achieving the same result by chance.

Communication, Scientific

With the increase in the support and activity in the worldwide scientific community, there has been increased attention given to the problems and science policies for improved information handling and communication.[5]

[5] S. Passman, *Scientific and Technological Communication* (Elmsford, N.Y.: Pergamon Press, 1969).

Consensus Forecasting

See Delphi Technique.

Conservation

This is a broad term generally conveying the idea of foregoing present benefits to reserve them for the future. Among the shades of meaning encompassed by the term are: preservation of natural beauty in an unspoiled condition, frugal use of a scarce and critical material, prevention of needless consumption or waste of any resource, reservation of supplies of a resource for allocation among essential uses, accumulation or protection of reserves of a resource to ensure its future availability, and the concept of (maximum) "sustained yield" of resources like forests. Compare Steady State and Homeostasis.

Constraint

A limiting condition to be satisfied in the design or operation of a system. For example, the total cost may be a constraint; another might be the percentage of system life consumed in down-time. Physical size or weight constraints may be required. Compatibility of a system with other systems may impose constraints. Sometimes it is not easy to distinguish between constraints and design objectives. For example, for a corporation to operate at a profit is sometimes considered an objective and sometimes a necessary constraint.

Corrosion

Corrosion is the deterioration of a metallic or nonmetallic material caused by a chemical interaction with its environment. The major materials subject to corrosion are metals, but corrosion of nonmetals, like the weathering of timber or concrete, is also important. Broad types of corrosion reactions involving metals are: (1) corrosion by electrolyte solutions, like the corrosion of zinc in hydrochloric acid; (2) corrosion by dry gaseous environments (usually at high temperatures); (3) corrosion by solvents, like liquid metals; and (4) the failure of metals under prolonged stress, through stress corrosion cracking.

Economic losses directly or indirectly attributable to corrosion are estimated to be some $15 to $20 billion a year. Corrosion problems are a limiting factor in the progress of areas like the exploration of the oceans and the development of better refining operations and chemical processing methods. Half of the current losses from corrosion could be prevented by full application of known technology. Anodic protection or cathodic protection, inhibitors, material selection, and the appropriate design of structures are methods used to control corrosion.

Cost/Benefit Analysis

(Compare Risk/Benefit Analysis)

The relation between social benefits and social costs associated with the operations of a technical system under study. The benefits and costs include direct and indirect effects. Monetary equivalents are

sometimes assigned to the non-materialistic values for the purposes of comparison and to clarify the relationships between benefits and costs.

A respondent offers the following amplification:

> Cost benefit analysis deals with decisions of two kinds: (a) engineering or building, and (b) policy. In either case, alternatives are defined and compared in terms of their cost and payoff. Type (a) refers to choices of weapons system designs, for example, and type (b) to [departmental] policy decisions. This definition could be referenced to [Cost Effectiveness] since historically cost-effectiveness analysis preceded cost-benefit analysis. In the military area, in which cost-effectiveness analysis originated, the payoff was defined in terms of effectiveness of the military system. In the civilian area, "effectiveness" is replaced by "benefit." Admittedly, benefits in social systems are even more difficult to define than effectiveness in military systems.

Another respondent suggests that the term Cost/Benefit Analysis signifies "a decision-making tool especially useful in obtaining a first ranking of large public projects in terms of their priority for implementation. There has been an increasing attempt to widen the scope of both cost and benefit to include effects that have no obvious market valuations."

Cost/Effectiveness (Also, Cost/Effectiveness Analysis)

This is a term widely used in systems analysis, and has been carried over into budgeting analysis. It signifies the ratio, over an explicit and finite time-span (such as product life in service), of cost in dollars and other tangible values to Effectiveness (q.v.) It should be noted that Cost/Effectiveness as an analytical expression is useful in dealing with tangible costs and measurable performance characteristics. Its application to programs with unpredictable results (such as scientific research projects) can lead to the undervaluing of the project. Experimental programs are not amenable to such analyses, except after the fact.

A definition used by the Research Analysis Corporation emphasizes the concept of precision:

> [Cost-Effectiveness Analysis is the] quantitative examination of alternative prospective systems for the purpose of identifying the preferred system and its associated equipment, organizations, etc. The examination aims at finding more precise answers to a question and not at justifying a conclusion. The analytical process includes trade-offs among alternatives, design of additional alternatives, and the measurement of the effectiveness and cost of the alternatives.[6]

Cost Out

In Program Analysis (q.v.), an early step in the assigning of monetary costs to the various program inputs required.

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[6] I. Heymont, O. Bryk, H. Linstone, and J. Surmeier, "Guide for Reviewers of Studies Containing Cost-Effectiveness Analysis," Economics and Costing Department Study 63.2 (McLean, Va.: Research Analysis Corp., October 1965).

Creativity

A capacity for novel association as, for example, of ideas, principles, phenomena, or artifacts to produce a useful or purposeful result.

Criterion (plural Criteria)

A Standard (q.v.) or an explicit measure by which to evaluate any thing or activity. Criteria may be quantitative or qualitative and objective or subjective. In Effectiveness analysis, criteria are the elements to be measured to determine costs and benefits. In Policy Analysis, criteria are separate considerations employed to eliminate alternative options, or to establish priorities or preferences among options.

Cross Impact Matrix Analysis

This is a method of correlation based on the assumption that every event under consideration can be assigned a probability of occurrence. By analysis, on the basis of estimated interdependency among the different events considered, an adjusted probability estimate of each event can be produced. For discussion of the technique, see:

T. J. Gordon and H. Hayward, "Initial Experiments with the Cross-Impact Matrix Method of Forecasting," *Futures*, Vol. 1, No. 2 (December 1968), pages 100–116.

Howard Johnson, "Some Computational Aspects of Cross-Impact Matrix Forecasting," *Futures*, Vol. 2, No. 2 (June 1970), pages 12–131.

Richard Rochberg, "Information Theory, Cross-Impact Matrices, and Pivotal Events," *Technological Forecasting and Social Change*, Vol. 2, No. 1 (1970), pages 53–60.

T. J. Gordon, "Cross-Impact Matrices," *Futures*, Vol. 1, No. 6 (December 1969), pages 527–531.

R. Rochberg, et al., *The Use of Cross-Impact Matrices for Forecasting and Planning* (Middletown, Conn.: Institute for the Future, April 1970).

Selwyn Enzer, et al., *Futures Research as an Aid to Government Planning in Canada*, Report R–22, (Middletown, Conn.: Institute for the Future, August 1971).

A different technique with a similar name, Cross-Support Analysis (also called "Decision Impact Analysis"), is described as a method "to aid in technological forecasting by the study and operational analysis of the effect of making and implementing complex decisions which affect and are affected by a large number of factors." For an illustration of this technique, see Christine A. Ralph, "The Beginnings, of Cross-Support Analysis (DIAMA) as Applied to the Fishing Industry," in Marvin J. Cetron and Christine A. Ralph, *Industrial Applications of Technological Forecasting* (New York: Wiley-Interscience, 1971), page 274.

Cross-Sectional Data

See Longitudinal Data.

Cultural Lag

This term implies a comparison. It may refer, alternatively, to the fields of intellectual activity in a country that are relatively less developed than are other fields, or to a country in which the fields of intellectual activity are generally less developed than in other countries.

Cybernetics

See Communication(s) (and Communication Theory).

Data Base (Also, Data Bank)

A collection of factual information, particularly when deposited in the memory core of a computer ("stored"), organized or structured by categories pertinent to a problem area, and accessible to be called out or consulted.

Decision Theory

Even when all extraneous variables are held as closely under control as possible—as in an elegant scientific experiment—the finding is still probabilistic. See Science. In the management of social programs, control of variables is much more partial. Accordingly, in choosing among Options (q.v.) in program management, the manager or decisionmaker always makes his decision on the basis of partial and incomplete information. Decision Theory is the term applied to the array of mathematical and other logical tools and procedures of Systems Analysis (q.v.) that may help to focus the issue and give guidance toward a rational decision under these conditions. The goal of a "good" decision, under this theory, is to maximize the probability of favorable outcome.

Delphi Method (Also, Consensus Forecasting)

This is a term referring to one type of procedure, developed by Messrs. Dalke and Helmer of the Rand Corporation, for the forecasting of time-related future events. It has been most commonly employed in the estimating of the probable time of achievement of specific technological or social goals. The technique involves the repeated ("iterative") consulting with numbers of informed persons as to their best judgment as to when a specified event is likely to occur (i.e., when it *will* occur, not when it *should*), and providing them with systematic reports as to the totality of judgments rendered by the group. The responses of all participants are assembled and returned to the participants, inviting them to reconsider and to offer any defense they may have for an estimate that seems out of line with others made by the group. This information, and revised estimates, may then be circulated to the participants for further analysis and so on. The procedure can vary considerably, but its primary utility is that it produces a well-considered consensus of the intuitions of a plurality of informed witnesses without injecting the bias of leadership influence, face-to-face

confrontation, or group dynamics. Respondents as individuals are expected to clarify their own thinking, and the final decisions—according to the theory, at least—will tend to converge by narrowing the range of estimates in response to the most convincing arguments.

Delta Chart

Graphic portrayal of a logical sequence in decisionmaking. It consists of a logical network of Decisions, Events, Logic, Time sequence, and Activity.

Developed/Developing/Undeveloped Nations

These are conceptual terms and encompass many characteristics. They are always relative, in the sense that no nation is fully developed or totally undeveloped, and rarely are all factors of development being developed at the same time. The state of being "developed" has reference generally to such factors as gross national product (GNP), education, level of technological development, industrial productivity, industrial infrastructure, health and welfare provisions, agricultural productivity, level of exploitation of available resources, and the like.

Development

Loosely, any intensification in the use of technology, whether to raise the economic level of a geographic region, or to provide concrete means of improving the performance of a function or program. As distinguished from Research (q.v.), Development is the employment of available information in the construction of a piece of operating hardware or a useful process, physical or social. In the usage of science policy, Development signifies the systematic use of the knowledge and understanding gained from scientific research directed toward the production of useful materials, devices, or methods, including design and construction of prototypes and demonstration of processes. In industrial practice, the term "pilot plant" is often used to refer to a principal phase of the process of Development—the proving out on a small scale of a new industrial concept.

Diffusion (of Technology) (Also, Diffusion of Innovation)

Some persons distinguish between the first application of a new technology (i.e., the transfer of technology from the applied research phase to application) and subsequent, more general application of it. The term, Diffusion, is commonly applied to the transfer of a new technology from the first commercial use to a number of competing users.

Discounting

Introduction of the economic factor of the future cost of capital, to be charged against realized future income produced by a proposed investment of the capital. For investments yielding returns in the very long range future, the discount can be a major percentage of the total investment.

Ecology

The biologist Haekel coined the term "ecology" about 1870 by combining the Greek roots oikos (house) and logos (study) ; literally, the term means the study of organisms "at home." Odum, in *The Fundamentals of Ecology*, states:

> Usually ecology is defined as the study of the relation of organisms or groups of organisms to their environment, or the science of the interrelations between living organisms and their environment. Because ecology is concerned especially with the biology of *groups* of organisms and with *functional* processes on the lands, in the oceans, and in fresh waters, it is more in keeping with the modern emphasis to define ecology as the study of the structure and function of nature, it being understood that mankind is a part of nature. . . . In the long run the best definition for a broad subject field is probably the shortest and least technical one, as, for example, "environmental biology."

Laymen frequently use the word to refer to the environment itself, rather than to refer to its study. In this loose usage "ecologist" may be anyone interested in or concerned about the environment, rather than a biological scientist. Thus, in a letter to Science magazine, July 14, 1972, Bruce L. Welch of Johns Hopkins University asked: "What is an ecologist? One who has graduated from a curriculum bearing the name 'ecology'? A member of a professional 'ecological society'? Or one who holds the point of view that an organism's interactions with its environment are important, and who seeks to rigorously define the natural rules by which these interactions are determined?"

Econometrics

The application of statistical and mathematical techniques in solving problems as well as in testing and demonstrating theories relating to matters of economics.

Economic Indicators

Statistical series reflecting changes in the national economy over time. Examples include: gross national product, wholesale price index, unemployment level (aggregated and disaggregated by categories), disposable income, new capital formation, etc. An important impetus was given to the use of Economic Indicators by enactment of the Employment Act of 1946, Public Law 79–304, 60 Stat. 33, approved February 20, 1946. This measure declared it to be the "continuing policy and responsibility of the Federal Government" to manage its affairs to "promote maximum employment, production, and purchasing power." To coordinate this effort, there was created a Council of Economic Advisers, one of whose functions was (sec. 4(c) (2) :

> —to gather timely and authoritative information concerning economic developments and economic trends, both current and prospective, to analyze and interpret such information * * * for the purpose of determining whether such developments and trends are interfering, or are likely to

interfere, with the achievement of [the indicated policy], and to compile and submit to the President studies relating to such developments and trends.

See also Social Indicators.

Ecosystem

The ecosystem, the basic functional unit in ecology, is "any area of nature that includes living organisms and nonliving substances interacting to produce an exchange of materials between the living and nonliving parts." (Odum, *Fundamentals of Ecology.*) An example of an ecosystem is a lake.

An ecosystem is conveniently described in terms of four constituents: "(1) abiotic substances, basic organic and inorganic compounds of the environment; (2) producers, autotrophic organisms, largely green plants, which are able to manufacture food from simple inorganic substances; (3) consumers (or macroconsumers), heterotrophic organisms, chiefly animals, which ingest other organisms or particulate organic matter; (4) decomposers (micro-consumers, saprobes or saprophytes), heterotrophic organisms, chiefly bacteria and fungi, which break down the complex compounds of dead protoplasms, absorb some of the decomposition products, and release simple substances usable by the producers."

Effectiveness

In systems analysis, the term Effectiveness is an aggregative expression intended to encompass all performance qualities of a system that the customer judges—or is likely to judge—as relevant. The term describes a condition in which the system or program possessing it has been designed to satisfy at some pre-determined level all criteria selected as relevant. The term does not imply perfection but essential adequacy in all significant categories of performance. An Effective design will result from the total of design decisions among Options (q.v.), selecting the optimal Trade-Off (q.v.) at each decision point, to satisfy all conceivably relevant internal and external criteria, quantitative and qualitative, tangible and intangible, of performance and environmental compatibility. The concept includes such obvious criteria as cost, efficiency, and reliability. It also involves total life (or "Life Cycle") cost, maintainability, maintenance of state-of-the-art modernity, manufiability, training, compatibility with expected operating environment, recycle or scrap value, and such other criteria as the design engineer and the customer consider relevant.

The term has carried over into wide use of budgetary and analysis purposes, such as in Cost/Effectiveness (q.v.).

Efficiency

A concept of mechanics: output divided by input. (The higher the efficiency of a system, the closer Efficiency is to unity; it is always expressed as a percentage less than one.)

The term Efficiency is also used more loosely to indicate an input--output relationship of incommensurables. Viz., an increase in output without an increase in input, or maintained level of output with re-

duced level of input indicates increased "Efficiency" even though neither term is quantifiable. Still more loosely, the term is sometimes used to refer to increased output per unit of time with a given set of factors of production.

Electromagnetic Spectrum

The electromagnetic spectrum is the full continuum of radiant energy which is transmitted through space or materials in the form of electromagnetic waves, either from natural (terrestrial or extraterrestrial) or man-made sources. Although electromagnetic radiation is generally treated as being in wave form, it may also be treated as consisting of discrete particles or quanta, like photons of light.

The full range of electromagnetic radiation extends from cosmic photons with a Frequency (q.v.) of 10^{23} Hz (Hertz) and a wavelength of 3×10^{-15} meters through commutated direct current with a frequency of 1 Hz and a wavelength of 3×10^{18} meters to direct current supplied by batteries with zero frequency and infinite wavelength. The electromagnetic spectrum includes, starting from the high frequency end, gamma rays, X-rays, ultraviolet radiation, the spectrum of visible light, infrared radiation, microwaves, radar, television FM radio, shortwave radio, AM radio, longwave radio, and induction heating radiation.

Sources of electromagnetic radiation include extraterrestrial sources, radioactive nuclei, inner atomic shells, atoms in sparks and arcs, hot bodies, electronic devices, rotation machinery, and batteries.

Empirical (adjective)

Based upon experience or experiment alone, without using science or theory; *a posteriori* (from effect to cause), based upon actual observation or experimental data; opposed to *a priori* (from cause to effect), based upon reasoning processes (theory) independently of actual observation or experimental data.

Empiricism (noun)

A method based extensively or entirely upon experience or experiment with little or no reliance upon science or theory. Sometimes called "Edisonian" research because the famous inventor Thomas Alva Edison relied heavily on "cut and try" experimental methods. Empiricism bears some relation also to the philosophic term "pragmatism"—i.e., "that which proves effective" as against "that which is supported by theory or hypotheses."

Energy

Energy is the capacity to do work. It involves a force acting over a distance to move a mass or overcome a resistance. Energy takes chemical, mechanical, electrical, thermal, nuclear, radiant, and gravitational forms. A spring can be compressed to store mechanical energy and do work as it returns to its relaxed shape or position; a charge of gunpowder has chemical energy and does work by burning explosively. A mass may possess energy by the nature of its physical position (potential energy) or by the nature of its motion (kinetic energy). Scientists use different units to quantify its various forms. Physicists use joules,

ergs, and electron volts; biologists use calories; and engineers use British thermal units (Btu) and kilowatt-hours. Quantities of energy are mathematically equated to each other by conversion equations like: 1 joule = 10 million ergs; 4.184 joules = 1 calorie; and 1.34 horsepower-hours = 1 kilowatt-hour.

Energy tends to change from one form to another, usually ending up as heat. (Cf. Energy Conversion.)

The Btu, an amount of heat required to raise the temperature of one pound of water one degree Fahrenheit, has evolved as a common energy unit. The Btu equivalents of certain fuels and electrical production are the following:

	Btu.
Crude oil, 1 barrel	5,800,000
Natural gas, 1 cubic foot	1,032
Coal, 1 ton	24–28,000,000
Electrical production, 1 kilowatt-hour	3,412

Because the Btu is a small amount of energy, large quantities are often expressed as exponentials (10^{12} or 10^{15}, e.g.) of the Btu. See Quad.

Energy Conversion

Energy (q.v.) exists in a number of forms and is capable of being changed from one form to another in many ways.

The burning of coal to convert chemical energy to heat, the use of solar energy to provide electricity to heat or cool a house, and the cellular metabolism of food to provide a living body with calories are examples of energy conversion. In any energy process, some of the energy is converted to heat or light or is otherwise lost to the system. Consequently, after conversion, the remaining energy can do less work than previously. In this sense, the transformation of energy from one form to another is never 100 percent efficient.

Einstein's famous formula $E = mc^2$ equates energy with mass "m" and the speed of light "c". According to this equation, if one kilogram of matter is entirely converted into electrical energy, it yields 25 billion kilowatt-hours of electricity.

Engineering

The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind.[7] It is possible that this definition is too severe in excluding the contributions to engineering design of psychology and anthropology (human factors engineering), biology and medical research (bioengineering), and the long lists of specialized disciplines required for systems engineering.

Entropy

Entropy is an abstract concept of the process of loss in the relative order or arrangement of the constituent elements of a closed system. It is "measured" in terms of the energy flows or the arrangement of

[7] Definition supplied by Engineers Council for Professional Development.

molecules in the system. A highly ordered structure, like a pure crystal, has low entropy. The random molecular arrangement of a gas has high entropy.

In the systems concept, the purpose of the system is to preserve low entropy, in other words to maintain stability by adapting to change in external or internal stresses, without loss of its operational character. The terms Steady State and Homeostasis (q.v.) are used in different disciplines to convey a similar meaning.

Environment

This term refers to the total set of things, influences, conditions, and forces in relation to some referent. One may speak of the environment within some space or volume (organism, city, ocean, etc.) or of the environment surrounding some locus (organism, hill, planet, etc.).

The most common usage of the term is in a biological or, more broadly, a natural science sense in reference to the total surroundings of the earth: air, land, water, flora and fauna (including man), radiation from space, and so on. These surroundings include both active and passive elements. Occasionally the term is used by laymen in a sense differentiating the so-called natural environment from man and his activities, as in the expression "man's destruction of the environment."

The concept of "environment" has proved so meaningful that the word has become incorporated into the jargon of many disciplines with slightly altered references. For example: businessmen may speak of the "business environment," referring to the totality of social, economic, political, and technological forces within which their business is conducted. Systems analysts use the term to refer to all relevant elements or forces external to and impacting on a system and also to all relevant elements or forces within a system that impact on components of it.

Environmental Impact Statement(s) (Also, Impact Statement(s), 102 Statement(s), 102 Report(s))

An analysis of the environmental implications of actions by agencies of the Federal Government: such analyses are prepared by Federal agencies pursuant to Section 102 of the National Environmental Policy Act of 1969 (NEPA) (Public Law 91–190, approved Jan. 1, 1970). Section 102 requires all Federal agencies to interpret and administer all policies, regulations, and laws in accordance with NEPA, to utilize "a systematic, interdisciplinary approach . . ." in planning and in decision-making which may have an impact on man's environment, and to—

> include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—
>
> (i) the environmental impact of the proposed action,
>
> (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
>
> (iii) alternatives to the proposed action,

(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

The Council on Environmental Quality (CEQ) is responsible for overseeing the process of preparing 102 Statements and for reviewing them. Pursuant to Executive Order 11514, the CEQ, established Guidelines on Environmental Impact Statements (36 Fed. Reg. 7724–7729, April 23, 1971): and it has overseen the issuance of the procedures used by Federal agencies to implement Section 102 (36 Fed. Reg. 23666, Dec. 11, 1971). New revised Guidelines for the Preparation of Environmental Impact Statements were published in the *Federal Register* (38 Fed. Reg. 20550–20562, August 1, 1973).

By early 1975, some 600 Environmental impact statements had been received by the CEQ, about half from the Department of Transportation concerning airports and highways. The CEQ checks the reports for compliance with NEPA, identifies problem areas for possible correction, and monitors significant or controversial actions.

Through the 102 Statements, NEPA is established as an information mechanism: it requires systematic comprehensive consideration of environmental implications of actions, evaluation of alternatives, and the development of in-house expertise. The requirements of NEPA, including in particular the adequacy of the 102 Statements, have been upheld by the courts.

These statements are circulated in draft form to other agencies for comment, and also are made public. A catalog of 102 Statements is prepared monthly by the CEQ and is called the "102 Monitor."

Ergonomics

According to *Dorland's Illustrated Medical Dictionary* 24th Edition, Ergonomics is the "science relating to man and his work, embodying the anatomic, physiologic, psychologic, and mechanical principles affecting the efficient use of human energy."

Externalities (Also, External Effects)

This term can be defined in at least three ways: as an economic term, as an element of communications theory, or as a factor relating to social systems. Economically speaking, externalities are costs or benefits not taken into account in a transaction or system of transactions. In this usage, the right of an industry to pollute a stream (i.e., a "free good") when it is not charged against the cost of doing business would be an Externality. In Communications Theory, an Externality is an aspect of the operation of a system that generates no Feedback (q.v.). As applied to social systems, an Externality is an aspect of changed environmental stress that has not been perceived or has not motivated an adaptive adjustment of the organism or social system.

Facsimile (Facsimile Transmission)

The transmission of a fixed image, like a photograph, handwriting, map, or drawing, by wire or radio. Most facsimile equipment in the United States today is used for telegrams, but other uses are increasing rapidly, including business document transmission, weather charts, newspaper photographs, railroad waybills, and cloud-cover photographs from signals sent by satellites.

For black and white transmission, an image is divided into small areas (each typically .01 x .01 inch) and each area is then transmitted as an electrical signal according to its degree of shading from white to black. Color fascimile transmission is now possible using multiple transmissions representing different colors.

Feedback

"The control of a machine on the basis of its *actual* performance rather than its expected performance is known as feedback, and involves sensory members which are actuated by motor members and perform the function of tell-tales or monitors—that is, elements which indicate a performance. It is the function of these mechanisms to control the mechanical tendency toward disorganization; in other words, to produce a temporary and local reversal of the normal direction of entropy." [8]

The concept of Feedback is extended by Wiener to human and information systems, as well as to mechanical systems. He writes:

> It is my thesis that the physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback. Both of them have sensory receptors as one state in their cycle of operation; that is, in both of them there exists a special apparatus for collecting information from the outer world at low energy levels, and for making it available in the operation of the individual or of the machine. In both cases these external messages are not taken neat, but through the internal transforming powers of the apparatus, whether it be alive or dead. The information is then turned into a new form available for the further stages of performance. In both the animal and the machine this performance is made to be effective on the outer world. In both of them, their *performed* action on the outer world, and not merely their *intended* action, is reported back to the central regulatory apparatus.[9]

Elsewhere, Wiener relates Feedback to learning:

> * * * *Feedback*, the property of being able to adjust future conduct by past performance. Feedback may be as simple as that of the common reflex, or it may be a higher order feed-

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[8] Norbert Wiener, *The Human Use of Human Beings, Cybernetics and Society* (Garden City, N.Y.: Doubleday & Co., Inc., 1954), pp. 24–25.
[9] Ibid., pp. 26–27.

> back, in which past experience is used not only to regulate specific movements, but also whole policies of behavior.

Such a policy-feedback may, and often does, appear to be what we know under one aspect as a conditioned reflex, and under another as learning.[10]

Positive feedback amplifies, enhances, or stimulates the performance of a machine or system. Negative feedback dampens, diminishes, or discourages the performance or adaptive response of a machine or system.

Food Chains

The transfer of food energy from the source in plants through a series of organisms with repeated eating and being eaten is referred to as the *food chain*. At each transfer a large proportion, 80 to 90 percent, of the potential energy is lost as heat. Therefore, the number of steps or "links" in a sequence is limited, usually to four or five. The shorter the food chain (or the nearer the organism to the beginning of the chain), the greater the available energy. Food chains are of two basic types: the *grazing food chain*, which, starting from a green plant base, goes to grazing herbivores (i.e., organisms eating living plants) and on to carnivores (i.e., animal eaters); and the *detritus food chain*, which goes from dead organic matter into microorganisms and then to detritus-feeding organisms (detritivores) and their predators. Food chains are not isolated sequences but are interconnected with one another.[11]

Forecast (Also, Forecasting)

See also Futures Research, Prediction.

Loosely, Forecast is synonymous with Prediction. However, it is properly distinguished from it in that a Forecast is a probabilistic statement at a relatively high confidence level that a specified event will occur by a specified future time or within some specified time period. A respondent offers the following list of methodological types of Forecasting: probabilistic forecasting, Delphi techniques, gaming, cross impact analysis, scenario building, extrapolation techniques, contextual mapping, precursive analysis, brainstorming, statistical models, expert panels, relevance trees, network analysis, historical analogy, operation models, individual "expert" forecasting, simulation, and causal modeling.

Forecasting, Exploratory

This general approach to technology forecasting starts from a base of accumulated knowledge in relevant areas in order to project future technological parameters or functional capabilities or both.

(Cf. Forecasting, Normative and see Normative.)

Forecasting, Normative

This is a form of forecasting in which the starting point is not the question of feasibility but rather a determination as to what option might be of social value at some future time. Thus—

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[10] Ibid., p. 33.

[11] Eugene P. Odum, *Fundamentals of Ecology*, third edition (Philadelphia: W. B. Saunders Co., 1971), p. 63.

> When the forecast is "needs oriented", it is termed "normative." In the normative forecast, goals, needs, objectives, or desires are specified, and the forecast works backward to the present to see what capabilities now exist or could be extrapolated to meet future goals. In some cases the goal may even force technology. Indeed, the remoteness of the goals and the priority they have may well determine how many concurrent approaches are pursued to meet the goal.[12]

The author adds: "Normative forecasting probably should be called 'goal oriented planning'." On this last point, a respondent comments: "Actually, it is difficult to imagine planning that is not goal-oriented."
(Cf. Forecasting, Exploratory and see Normative.)

Futures Research (Also, Futurism, Forecasting, Futurist)

See Forecast, and Delphi Technique.
Futures Research encompasses various attempts to develop systematic methodologies to identify future Options (q.v.) or alternatives, or to narrow probabilities of time estimates. See James Bright, ed., *Technological Forecasting for Industry and Government* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968); and Cetron and Ralph, *Industrial Applications of Technological Forecasting*, ibid.

Game Theory

Game theory can be defined as the application of mathematical analysis to abstract models of conflict situations. Models can consist of parlor games or situations from the behavioral sciences, including economics, sociology, and political science. Parlor games are generally in "extensive" form, that is, they are specified by a set of rules and are terminated after a finite number of moves. Models from the behavioral sciences are generally in "normalized" form, that is, they are specified by a set of pure strategies which could be followed by suitably instructed neutral observers. Pure strategies are complete lists of choices of legal moves covering all possible responses to legal opposing moves. Due to the enormous number of pure strategies possible in even a relatively simple model, applications of game theory to real-life situations have been severely limited by computational difficulties. However, game theory nonetheless has provided a means for analyzing many problems long of interest to philosophers and behavioral scientists. Of primary interest has been the concept of the welfare state, the theory of monopoly, the concept of the maximum good for the maximum number, and oligipolistic competition.

Genetic Engineering

The change of undesirable genes to more desirable forms by a process of directed mutation (or) the prospect of being able to insert, deliberately, specific factors (genes) into the genetic material, (or) the direct manipulation of the genetic message by changing, subtracting, or

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[12] Bright, *Technical Forecasting for Government and Industry, op. cit.*, p. 165. See especially Marvin J. Cetron and Thomas I. Monahan, "An Evaluation and Appraisal of Various Approaches to Technological Forecasting," in this text.

adding to the instructions received by the cell.[13] Many discussions of this topic have included such subjects as eugenics, artificial insemination, "test-tube" babies, cloning, counseling, medical genetics, and euthenics.

Global Effects

Changes in the climate, habitability, fauna and flora, ocean, atmosphere, land masses, or other large element of the Earth, resulting from human activities. The concept of Global Effects as a subject warranting study emerged from three contemporary developments: (1) the recognition of the Earth as a "spaceship" possessing finite resources and complex natural relationships on which man depends; (2) the increasing power of man's technology; and (3) the increasing rate of diffusion of this technology. Fears have been expressed "of both imminent and potential global environmental catastrophes."

Theories and speculations of the global effects of pollution have included assertions that the buildup of CO_2 from fossil fuel combustion might warm up the planet and cause the polar ice to melt, thus raising the sea level several hundred feet and submerging coastal cities.

Equally foreboding has been the warning of the possibility that particles emitted into the air from industrial, energy, and transportation processes might prevent some sunlight from reaching the Earth's surface, thus lowering global temperature and beginning a new ice age. The U.S. Government has virtually eliminated the use of DDT, largely because of its adverse effects on the reproductive capabilities of birds, and because of its accumulation in other species, including man. Serious questions have been raised about the effects on ocean and terrestrial ecosystems of systematically discharging into the environment such toxic materials as heavy metals, oil, and radioactive substances; or of such nutrients as phosphorus which can overenrich lakes and coastal waters.[14]

Goals, National

In general, these are outcomes, options, conditions, or relationships of large or national scope, held socially desirable by a consensus of persons, by groups, influential spokesmen, or political decisionmakers. They may be formalized, informal, or tacit. There are many mechanisms by which national goals are proposed, considered, and promulgated; there are also many ways by which they are modified, superseded, abandoned, or reduced in force.[15]

National goals may be formulated of different scope or character. For example, there are philosophical goals that state a nation's values

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[13] These three definitions, in the order given, appear in: (1) Donald Huisingh, "Should Man Control His Genetic Future?", *Zygon*, vol. 42 (February 1969), p. 189; (2) Gordon Rattray Taylor, *The Biological Time Bomb* (New York: New American Library, 1968), p. 159; and (3) I. Michael Lerner, *Heredity, Evolution, and Society* (San Francisco: W. H. Freeman & Co., 1968), p. 273.

[14] Report of the Study of Critical Environmental Problems (SCEP), *Man's Impact on the Global Environment, Assessment and Recommendations for Action, Report of the Study of Critical Environmental Problems*—SCEP (Cambridge, Mass.: Massachusetts Institute of Technology, 1970), p. 4.

[15] For a general discussion of national goals, see the Report of the National Goals Staff: "Toward Balanced Growth: Quantity with Quality" (Washington, D.C., U.S. Government Printing Office, July 4, 1970). See also: Franklin P. Huddle, "The Evolution and Dynamics of National Goals in the United States," Committee on Interior and Insular Affairs, U.S. Senate, 92d Cong., 1st Sess. (Washington, D.C., U.S. Government Printing Office, Aug. 6, 1971). For a methodology of "Costing Out" national goals, see Leonard Lecht, "Goals, Priorities, and Dollars" (New York: The Free Press, 1966).

or formal governmental purposes (such as liberty, welfare, tranquility, and security). There are social goals, expressing aspirations for improvement in a social function (such as literacy, or living standards), or the correction of social defects (such as crime rates or ill health). Political or legislative goals may take the form of formal statements of desired public objectives issued in legislative form by a law-making body (such as the "Finding of the Congress that. . . ."). Agency goals are expressed initially in the form of legislation—the organic acts creating departments and agencies of government and defining their missions; these are interpreted administratively as expanded mission statements and communications to the public. Pursuant to the agency goals are program goals, and at a still finer-grain level of specificity are project goals.

National goals can provide a frame of reference to establish priorities to which science policy can respond in the allocation of resources, and program selection and emphasis. See "Science, Growth, and Society, A New Perspective," Report of the Secretary-General's Ad Hoc Group on New Concepts of Science Policy—the "Brooks Report" (Paris: Organisation for Cooperation and Development, March 28, 1971).

Hardware

Originally, tools and other household, farm, and repair items. With the advent of the computer, the term has come to mean the computer itself and its associated equipment, like control consoles, memory units, key-sort and card-punch equipment, tape recording and drive equipment, print-out units, and telecommunications terminal and transmission equipment. Computer hardware is distinguished from the programming procedures used to operate it. These are called "Software" (q.v.).

Heuristic (adjective)

According to Webster's Third New International Dictionary, "Heuristic" refers to an approach "valuable for stimulating or conducting empirical [q.v.] research but unproved or incapable of proof—often used of arguments, methods, or constructs that assume or postulate what remains to be proven or that lead a person to find out for himself."

Heuristics (noun)

The study of the mental processes and stages involved in solving problems, including the perception of the problem, obtaining relevant information, a passive period of waiting for insight, and the solution of the problem, or insight.

Holistic (adjective)

An approach to research, analysis, or other activities characterized by an emphasis on completeness or wholeness; opposed to the atomistic approach. It is related to the synergistic approach with its emphasis on the organic or functional relationship of the whole to its parts, and on the whole as being greater than the sum of its parts.

See Synergistic Effect(s).

Homeostasis

In biological usage, the term refers to a tendency of organisms to maintain uniformity or stability. For example, the human body normally maintains its internal temperature at about 98.6° F. The term has been applied by analogy to the maintenance by any system of a steady state condition of dynamic equilibrium.

Impact (as in Impact Analysis, Technological Impact, etc.)

For one formal statement of the scope of this term, see Environmental Impact Statements. However, the term is far from precise in most usages. The recognition of impacts tends to be a progressive, repetitive process because the impacts on man and his environment from any given technology, process, or system appear to be almost limitless. Some impacts are quantifiable, and some not. Various kinds of impact can have varying degrees of directness or remoteness as between cause and effect. (A classic example of remoteness is the illustration of the light sensitivity of silver salts as a cause of divorce—in which the chain of causality encompasses the Hollywood subculture.) The concept of Technology Assessment (q.v.) is the analysis of "total impact."

Impact Statement(s)

See Environmental Impact Statements.

Incremental (adjective)

Refers to any relatively small, usually positive, change in anything that can be quantified, like a change in temperature caused by a change in applied heat, or a change in demand caused by a change in supply.

In the jargon of public policy analysis, governmental decision making apparently based on little else than a decision to make small yearly across-the-board increases in existing programs is often termed "incrementalism," and is sometimes also disparagingly referred to as the "art of muddling through." However, many social processes show general trends over long periods of time, as, for example, the "secular" trend in reduced purchasing power of any national currency. Incremental adjustments are normally made in response to such secular trends as a matter of course.

Moreover, in any complex social process involving a long learning period (for one example, see Technology Assessment), incremental improvement is inherent and instant perfection improbable.

Indirect Effects

See Side Effects.

Information

See Communication(s) (and Communication Theory).

Infrastructure

Supporting elements. Usually applied in connection with some category of social, economic, or cultural activity. For example, a nation's scientific Infrastructure might be said to include arrangements for

financial support of scientific research, basic scientific educational institutions, the manufacture of precision measuring instruments, the management and dissemination of scientific data and information, the organization of scientific societies, and arrangements for interpreting to the public the meaning of scientific achievements.

A nation's technological infrastructure depends on many supporting conditions, including availability of capital, technical knowledge, favorable governmental structure, entrepreneurial attitude, effective distribution and marketing system, transportation, communications, health services and facilities, education, and many more.[16]

Innovation

Compare Invention.

Innovation is a term used to signify either the product of a complex series of activities, or the process itself. It includes (1) a perception of a problem or opportunity, perhaps using Exploratory Forecasting (see Forecasting, Exploratory); (2) a "first conception" or invention of an original idea; (3) a succession of interwoven steps of research, development, engineering, design, market analysis, and management decisionmaking; and (4) a "first realization" or "culmination" when an industrially successful thing—a product, industrial procedure, or techniques—is first used in an economic, industrial, or social context (vertical transfer of technology), and perhaps also the adoption of the process or manufacture of the product by others in competition (diffusion or lateral transfer of technology).

Although sometimes used to signify the process itself, the word is also used as a modifier, in the term "innovative process."

Innovation, according to one view, should not be confused with: (1) scientific discovery, although relevant discoveries may be incorporated in an innovation; (2) invention, although an invention frequently provides the initial concept leading to an innovation; or (3) marginal improvement in an existing product, process, or technique. However, how much more than marginal an innovation ought to be to qualify as a true innovation is hard to determine.

Many inventions or new scientific or technological ideas do not go through the entire complex of activities from conception to culmination; many are abandoned at intermediate steps. Only those that go through the entire process and emerge as new and useful commercial products processes, or techniques can be accurately termed innovations.[17]

In describing a quick search of the literature of Innovation, Jervis identifies the definition in the preceding paragraph plus two others:

> An innovation is an idea, practice or object perceived as new by an individual. It matters little, so far as human behavior is concerned, whether or not an idea is 'objectively' new as measured by the lapse of time since its first use or discovery.
>
> Technological innovation (is) the technical, industrial and commercial steps which lead to the marketing of new manu-

[16] See: U.S. Congress. House, Committee on Foreign Affairs. *The Evolution of International Technology.* Prepared for the Subcommittee on National Security Policy and Scientific Developments by the Science Policy Research and Foreign Affairs Divisions, Legislative Reference Service, Library of Congress (Washington, D.C.: U.S. Government Printing Office, December 1970); pp. 35–41. [Committee Print.]

[17] Adapted from *Science, Technology, and Innovation*, prepared for the National Science Foundation (Columbus: Battelle Memorial Institute, 1973).

factured products and to the commercial use of new technical processes and equipment.

These definitions, taken from academic studies and government reports, show that there are three situations in which the designation 'innovation' may be used. The first example considers the attributes of some specific item, be it an idea, product, process or technique, and uses concepts of novelty or originality in classifying it as "an innovation". The next approach takes a different viewpoint and discards as relatively unimportant any notions of absolute novelty and concentrates instead on the originality as perceived by a specific adapter. This approach, however, retains focus on the innovation as a "thing." But the last definition is an example of many that see innovation as a set of activities, a process, which transforms ideas, concepts or scientific and technological potential into commercially available and useful products, processes or techniques.

Process definitions are in some ways the most useful if one is considering innovation from a managerial or decision-making viewpoint, because they can focus attention on the critical problem areas on which the outcome depends.[18]

See also Technology Transfer.

Interdisciplinary Research

See Research, Interdisciplinary.

Intergovernmental Science

Intergovernmental Science refers to institutional mechanisms, policies, or programs which involve the interaction of various governmental units—Federal, State, local, county, regional—for the purpose of encouraging the utilization of scientific and technical resources in meeting government responsibilities. Intergovernmental science may involve the establishment of "partnerships" or intergovernmental arrangements designed to promote the transfer and utilization of existing technology from one governmental level to another, or to generate capabilities for different governmental units to support individual research and development activities and develop needed scientific and technical resources. Intergovernmental science activities may be targeted at such public needs as transportation facilities; health care services; environmental protection; land use management; housing; and police and fire protection. Institutional or program mechanisms may involve the provision of financial support, manpower training facilities, technical assistance, information systems, or opportunities for cooperative research and development priority setting and program formulation.

Invention

Compare Innovation.

The conception of a new product or process. A respondent suggests: "A spontaneous creative act on the part of an individual." However, the spontaneous creative act might conceivably be performed by a group working in concert; moreover, the act has been known to occur

[18] Jervis, P., *"The Changing Pattern of Innovation," Physics in Technology*, vol. 6 (July 1975), p. 170.

more or less simultaneously with remote inventors, as in the classic instance of aluminum reduction. In any event, the concept of a "flash of insight" appears to be involved. A respondent suggests reference to Fred Scher, "Invention and Innovation in the Watt-Boulton Steam-Engine Venture," *Technology and Culture* (Spring, 1965), as an illustration of the invention-innovation process.

Inventions can range from the novel combination of known elements to the conception of an altogether novel principle. However, the term is not commonly applied to the creation of a large system (such as satellite communications systems or air defense systems) although these may incorporate applications of a number of inventions.

Irreversibility

A one-way process, or alternatively a process that can be reversed only with great difficulty. An illustration is the comment by Oscar Wilde on viewing Niagara Falls. He agreed that it was a remarkable sight, but that it would be even more remarkable if it went the other way. An example of irreversibility in the physical world would be a wet chemical reaction in which one of the products was removed from the solution, as either a precipitate or a gas.

One concept of irreversibility relates it to Entropy (q.v.). Every closed system tends to run down. In this sense, irreversibility is a quality inherent in closed systems found in nature.

In the narrower sense of social use of technology, irreversibility is found in the growing commitment or dependency of a social system or subsystem on a particular artifact or assortment of technological artifacts—pesticides, automobiles, telephones, drugs, vaccination, etc. Other irreversible effects are those related to the consumption of fossil fuels, or the extraction and use of minerals from concentrations in nature that result in their unrecoverable dispersal. For example, the making of graphite from petroleum, or the use of cobalt salts to make paint driers. Although irreversible effects are inherent in natural systems, the rate at which they occur is partially determined by human decisions.

The concept of irreversibility may depend primarily on the factor of time. For example, a catastrophic, large-scale generation of radioactivity might cause a train of events that could not be reversed in time to prevent permanent damage to man's environment.

One respondent comments: "Most situations that one would judge to be irreversible are so not because of physical barriers but owing to the magnitude of cost attached to reversal. This is particularly true of the commitment of social systems to given technologies."

Lagging Industries

An imprecise term conveying a sense of non-progress or level of performance, as measured by some parameter or set of parameters, below that of some referent industry or group of industries. See also Technological Lag and Technology Gap.

Lead Time

Lead time is the time between two implicitly or explicitly designated events, the second one generally being an objective or goal. In research

and development, lead time usually refers to the time between the beginning of a project, like the commitment of funds to develop an airplane, and the project's successful completion, which may be when a successful prototype flies or when new planes are in mass production. However, the term has come to be applied widely to any preparatory period, decision sequence, or time lag between signal and response. In concept, the term derives from an analogy with sports—the throwing of a ball to "lead" the running receiver, or aiming a shotgun in advance of a flying bird. The PERT (q.v.) concept links the sequence of events in a process with time lines, with the length of each line indicative of the length of time (lead time) required to complete or prepare for the event that follows it.

Longitudinal Data

Longitudinal data are data about a specific population over an extended period of time, generally months or years, in which the researcher returns at intervals to collect identical kinds of data from the same population under study. The term is frequently applied to data collected for social science research, including statistics of individual and family incomes, educational levels, places of residence, religious affiliations, jobs, attitudes, and political and other beliefs. The term may be contrasted with "cross-sectional data," which are data for different groups at one time. Longitudinal data collection, when feasible, is superior in information product to cross-sectional data collection. It represents a more advanced procedure, particularly in the social sciences.

When longitudinal data cannot be collected for a specific population over an extended period of time because of time or financial constraints or the dispersion of the population under study, data-gathering procedures may be applied to different, but hopefully comparable, populations at different times (the cross-sectional approach) to approximate longitudinal data collection. However, the inappropriate use of cross-sectional data to approximate longitudinal data may invalidate research, or at least render it relatively useless because of the assumptions introduced to qualify its inappropriate use.

Luddite (Also, Neo-Luddite, and Technophobe) (Antonym: Technophile)

According to the 11th Edition of the Encyclopaedia Britannica, Ned Ludd, a "person of weak intellect," in Leicestershire, England, had been tormented by boys in his village, had pursued them into a house, and, when they escaped, had vented his wrath on several frames used in making hosiery. Thereafter in the community, when mischief was done to such equipment it was blamed—more or less facetiously—on "Ludd." Then, in 1811, a series of organized economically-inspired riots broke out in and around Nottingham. The rioters concentrated their attention against new textile machinery which they feared would generate technological unemployment. The riots spread and worsened through 1816. They were terminated by a combination of repressive measures plus returning prosperity. The term "Luddites" was given to these rioters. It became generalized to include any organized move-

ment against labor-saving machinery, in much the same fashion as the term "saboteur" (originally referring to a worker who threw a wooden shoe or sabot into the machinery) has been generalized to mean any form of politically motivated destruction.

The term Neo-Luddite, however, refers to a quite different motivation for hostility to technological innovation. In general, it applies to those opposed to technology on value grounds, rather than for economic reasons. According to this point of view, opposition to technology is a moral position; economic determinism has been found inadequate to regulate the production and adoption of good technology while restraining the bad, or—according to another view—there are so many technological innovations that society is increasingly incapable of adjusting to them.

Magnetohydrodynamics (MHD)

MHD is a technology under development to produce electric energy in commercial quantity by burning coal or other fuels to obtain a very hot ionized gas (cf. Plasma) which is then passed directly through a magnetic field to generate electricity. Some experts suggest that MHD can be developed to a stage at which it would surpass current methods of generating electricity in thermal efficiency, operating costs, and environmental effects.

Management Engineering

The application of scientific and technological principles and training, operations research, and associated disciplines, to the maintenance of a high level of productivity at minimum cost in industrial enterprises. It includes such approaches as analytical study, application of improved methods and systems and operating procedures, quantity and quality measurements and controls, safety measures, and personnel administration.

Material (noun)

The difficulty in defining this word is in determining, what to exclude. One common meaning is: "A solid substance having a certain degree of permanence and intended either alone or combined with other objects, for well-specified uses." This definition is defective on many counts; it excludes liquids and gases, in which forms many useful industrial materials appear. Another defect is in the implicit assumption that a material must have present utility. The implication of this assumption is that a substance may be converted by technology from a non-material to a material, and then later be converted back into a non-material again. Another awkward complication is presented by the notion that a substance ceases to be a material when it is changed by processing.

For public policy purposes, Title II of Public Law 91–512, the Resource Recovery Act of 1970 (Title II bearing the separate title of "National Materials Policy Act of 1970"), defines (section 205) materials as "natural resources intended to be utilized by industry for the production of goods, with the exclusion of food." The exclusion of food in this case is arbitrary and functional, rather than logical.

It is suggested that in the modern sense of addressing the "Materials Cycle" (q.v.) it is necessary to use a definition as all-encompassing as possible. Thus, materials are stuff that things are made of or with, or could be. It includes both materials as they occur in nature and in their useful forms; it encompasses both materials in the (relatively) pure form and in their infinity of combination. Converting a substance or combination of substances into a useful shape does not take away its existence as a material: a razor blade is also a piece of stainless steel, a piece of material, whether it is in use or after it has been discarded. It is of no matter whether the material is in the form of a solid, a liquid, or a gas, it is still a material. Wood, when cut into lumber or pulped to make paper, or disintegrated into sawdust, does not lose its character as a "material."

Materials Cycle

All materials employed by man move in a "total materials cycle." From the earth and its atmosphere man takes ores, hydrocarbons, wood, oxygen, and other substances in crude form and extracts, refines, purifies, and converts them into simple metals, chemicals, and other basic raw materials. He modifies these raw materials to form alloys, ceramics, electronic materials, polymers, composites, and other compositions to meet performance requirements and from them makes shapes or parts for assembly into products. When its useful life is ended, the product returns to the earth as waste; or it may be dismantled to recover basic materials that reenter the cycle.

Implicit in the operation of the total materials cycle are strong three-way interactions among materials, the environment, and energy supply and demand. The condition of the environment depends in large degree on how carefully man moves materials through the cycle, at each stage of which impacts occur. As materials traverse the cycle they may represent an investment of energy in the sense that the energy expended to extract a metal from ore, or to reduce aluminum from its oxide, need not be expended again if the metal is recycled. Compare closed cycle.

Materials Management

Materials management is the application of scientific and technological principles and training to achieve the optimal usage of materials resources. It is a broad concept, not only because of the scope of the meaning of materials (see Material), but also because it encompasses all aspects of materials extraction, processing, utilization, marketing, disposal, and reuse. It thus includes such concepts as Resource Recovery (q.v.) and Recycling (q.v.), which represent specific management approaches to materials conservation and use. Traditionally considered more narrowly as the manipulation of materials by business and industry, it has come to include also the effect of materials use on society and the consequence of such use. Thus, it relies heavily upon the application of System(s) Analysis (q.v.) to achieve an optimal mix of various scientific, technological, economic, social, ethical, and political factors which impinge on the development and use of material resources for the good of society as a whole. Increasingly, a primary objective of materials management is the achievement, inso-

far as practicable, of a Closed Cycle (q.v.) for materials to ensure that maximum benefit is obtained from materials at minimum overall cost.

Materials Policy, National

The identification of those aspects of the total Materials Cycle (q.v.) for which concerted national actions will probably serve the public interest, and the prescription of what these actions should be. Title II of the Resource Recovery Act of 1970 (Public Law 91–512, approved October 27, 1970) is entitled the National Materials Policy Act of 1970. Its purpose is to "enhance environmental quality and conserve materials by developing a national materials policy to utilize present resources and technology more efficiently, to anticipate the future materials requirements of the Nation and the world, and to make recommendations on the supply, use, recovery, and disposal of materials." The Act created the National Commission on Materials Policy to make a full and complete investigation and study for the purpose of developing a national materials policy; the final report of the Commission was made to the Congress and the President in June 1973.[19]

MBO (Management by Objectives)

Management by Objectives, a term attributed to Peter F. Drucker [20] is a method of managing "by which members of an organization jointly establish its goals."

> Each member, with assistance from his superior, defines his area of responsibility; sets objectives that clearly state the results expected of him; and develops performance measures that can be used as guides for managing his unit and that will serve as standards for evaluating his contribution to the organization. There are four basic components of the MBO system: setting objectives, developing action plans, conducting periodic reviews, and appraising the annual performance.

The organizational benefits of MBO are claimed to be improved management performance, planning, coordination, control, flexibility, superior-subordinate relationships, and personal development.[21]

Drucker characterizes MBO as a philosophy of management which:

> rests on an analysis of the specific needs of the management group and the obstacles it faces. It rests on a concept of human action, behavior, and motivation. Finally, it applies to every manager, whatever his level and function, and to any organization whether large or small. It ensures performance by converting objective needs into personal goals.[22]

A recent article in *Public Administration Review* discusses public sector MBO and PPBS (q.v.) and provides the following comparison of the major features of the two management techniques [23]:

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[19] U.S. Congress, Senate, *Material Needs and the Environment Today and Tomorrow: Final Report of the National Commission on Materials Policy,* 93d Cong. 2d Sess. (Washington, D.C.: U.S. Government Printing Office, June 1973). [Document No. 93–97.]

[20] Drucker, Peter F., *Practice of Management* (London: Pan, 1968), 479 p.

[21] Reif, William E. and Gerald Bassford, "What MBO Really Is," *Business Horizons,* vol. 16 (June 1973), p. 26.

[22] Drucker, Peter F., *Management: Tasks, Responsibilities, Practices* (New York: Harper and Row, Publishers, 1974), p. 442.

[23] De Woolfson, Bruce H., Jr., "Public Sector MBO and PPB: Cross Fertilization in Management Systems," *Public Administration Review,* vol. 35 (July-August 1975), pp. 387–395.

> [C]omparing MBO and PPB is like comparing apples with oranges. The two entities are not viewed strictly as alternative management systems. Rather, they have a somewhat different focus and tend to exist in different organizational environments. In particular, PPB is primarily viewed as a system for conceiving, developing, and costing new policy thrusts and is located organizationally near the top of large, sprawling bureaucracies. MBO conversely, is appropriate at any organizational level and is basically a tool for monitoring ongoing programs. The distinction however is very ill-defined; for in MBO the process of deciding what one's objectives for the future will be must certainly relate very closely to the choice of new policies and programs. PPB on the other hand cannot function in an operational vacuum but must at least monitor, if not motivate, the accomplishment of ongoing programs as a means for refining the basis of continuing analysis. Also, as evidenced by the recent MBO efforts in the Office of Management and Budget, the two systems will at times be superimposed upon one another, will follow one another in succession, or may in fact exist side by side.

Summary of Features

MBO	PPB
Makes objectives explicit; recognizes multi-objective situation	Projects requirements and resource implications in future years
Identifies conflicting objectives	Emphasizes analysis of alternatives
Provides for participative management	Utilizes analytical expertise
Ensures a control mechanism by providing for feedback and measurement of accomplishment	Provides for detailed costing of selected alternatives
Fosters managerial acceptance of responsibility and evaluation of managers by results	Encompasses exhaustive and mutually exclusive program structure
Encompasses little formal administrative machinery	Utilizes numerous decision documents

Mission

A single large operation or task, or a continuing specific function. Examples of missions might include the construction of a number of housing units, capture of a hill, development of a prototype fast breeder reactor, maintenance of national air superiority, achievement of improved pollution control or automobile safety. A distinction may be made between an agency of government performing a continuous or repetitive function such as budgetary control or revenue administration, and an agency responsible for carrying out some one of the missions listed. The latter might be called a "Mission Agency" but probably not the former. Mission Research is a term with several possible alternative meanings: it encompasses exploratory research, applied research, and supporting research to advance the general capability of a Mission Agency to perform; and also research of these types in support of a specific task or mission as more narrowly defined. It is with respect to the latter type that the study, Project Hindsight, was addressed.

Model

As used in science policy literature, the word signifies a simplified description of a process, or system, or the interaction of either with its environment. Usually a model is expressed in quantitative terms so that it can be exercised mathematically. A nonmathematical model is sometimes called a Paradigm (q.v.).

With respect to the science policy meaning of the word, a respondent notes: "An important thing about the model is that you try to walk the very fine line between shoving in to much detail (and then you can't use the model in practice) and leaving out essential details (in which case it will lead you astray)."

There are also two older meanings of the word Model: (1) a typical unit (e.g., late-model automobile), and (2) a reduced-scale structure to test performance or other characteristics of a design before going to full-scale prototype construction. From the second meaning is also derived the idea of a "scale model"—a reduced-size simulation of a structure that may or may not be operational.

Monitoring

An activity that evaluates on a continuous or periodic basis the Feedback (q.v.) from an operation against established criteria.

Multidisciplinary Research

See Research, Interdisciplinary.

Multinational Corporation

Although there is no agreed definition of the term "multinational corporation," it may be defined simply as a business enterprise conducting transnational operations in two or more countries.

> Some authorities define it as a company whose foreign sales have reached a ratio of, say, 25% (or some other share) of total sales. Some find the definition in organization; i.e., a company that has global product divisions rather than an international division. Others look to the distribution of ownership or to the nationality mix of managers or directors as the determining characteristic. Professor Raymond Vernon of Harvard University, an authority on the multinational corporation, regards it as a company that attempts to carry out its activities on an international scale, as though there were no national boundaries, on the basis of a common strategy directed from a corporate center. According to Vernon, affiliates are locked together in an integrated process and their policies are determined by the corporate center in terms of decisions relating to production, plant location, product mix, marketing, financing, etc. Mr. Jacques Maisonrouge, President of IBM World Trade Corporation, characterizes the multinational corporation as one that: (a) operates in many countries; (b) carries out research, development and

manufacturing in those countries: (c) has a multinational management; and (d) has multinational stock ownership.[24]

Some reasons often given for U.S. firms becoming multinational corporations are:

To cut the shipping time for products with short shelf lives;

To manufacture to special market requirements (smaller appliances, differing electrical requirements, and the like);

To be as close as possible to the customer to adapt to his needs and provide fast service;

To meet a government's purchasing policies by being within the country's borders;

To avoid the problems imposed by frequent strikes at U.S. ports;

To keep foreign firms so busy competing locally that they cannot effectively launch export campaigns aimed at the U.S.;

To be close to raw materials sources; and

To meet foreign "minimum local content" requirements.[25]

The number of U.S. multinational corporations ranges from 75 to more than 3,000, depending upon how they are defined. The Harvard School of Business Administration in its studies of U.S. multinational corporations, which comprise about two-thirds of the world's total, has taken the firms listed in the Fortune group of the 500 largest firms and selected those having equity interests of 25 percent or more in manufacturing enterprises located in six or more foreign countries. The 187 firms that qualified under this definition were studied extensively and account for about three-fourths of all U.S. foreign direct investments. Among these are such familiar names as General Motors, Chrysler, Ford, Singer, ESSO, and ITT. In addition, about another 100 foreign firms comprise the major multinationals based in other countries, including such companies as Nestle, Shell, and Unilever (Lever Brothers).

Multinational corporations are among the world's giant firms; annual sales of at least $100 million are considered a minimum size for a multinational.[26]

According to 1970 figures, General Motors ranks 23, Standard Oil (N.J.) ranks 27, and Ford Motors ranks 29 in a listing of countries and multinational corporations by the corporations' gross annual sales and the countries' gross national products.[27]

National Materials Policy

See Materials Policy, National.

Negative Feedback

See Feedback.

Neo-Luddite

See Luddite.

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[24] U.S. Department of Commerce, *The Multinational Corp.: Studies on U.S. Foreign Investment* (Washington: U.S. Govt. Print. Off., March 1972), p. 7.

[25] Reported in *Industry Week*, Jan. 8, 1973, p. 23.

[26] Janet Bancroft, *The Multinational Corp.: A Background Survey*, C.R.S. Report 72-244-F (Washington: Library of Congress, Dec. 20, 1972), pp. 1-2.

[27] Lester R. Brown, "The Multinationals and the Nation-State," *Vista*, vol. 8, June 1973, pp. 50-51.

Net Energy Analysis

In addition to land, labor, and capital (the commonly costed factors of production), it takes energy to produce energy. Net Energy may be defined as the amount remaining for consumption after the portion required for exploration, production, upgrading, and delivery has been subtracted from the total energy initially available in a specified system.

Net Energy Analysis is an evolving system of analysis currently being investigated and applied by, for example, the National Science Foundation, the Energy Research and Development Administration, and the Department of the Interior, to evaluate better the real energy costs of developing and using various energy sources. Energy itself is the parameter used to measure impacts in this method. "Since energy is the one commodity present in all processes and since there is no substitute for it, using energy as the physical measure of environmental and social impacts, of material, capital, and manpower requirements, and of reserve quantities reduces the need to compare or add 'apples and oranges.' "[28]

Net Energy Analysis may prove to be a useful decision-making tool for public policy analysis.

NIH (not invented here) Syndrome

The "not invented here" syndrome is alleged to be a characteristic of research and development. Its major symptom is a lack of interest by professionals in new ideas which have originated outside of their establishment, or perhaps even in another division of their establishment.

The NIH syndrome may be considered an organizational pathology, prevalent at both the research and management levels, which impedes communication (q.v.), innovation (q.v.), and technology transfer (q.v.). It is caused by a conviction, based on institutional pride or confidence, that "if it were any good we would have thought of it first."

Noise Pollution

Pollution may be defined as any deleterious and unacceptable substance or effect which cannot be assimilated or recycled by a system.[29]

Noise is a specific example of an effect which may be deleterious and unacceptable to many persons, depending upon its level. Noise is measured in decibels (dB), which is a logarithmic measure of sound energy used because of the nature of human response to sound, that is, a sound with ten times the energy of another is perceived by humans as being twice, not ten times, as loud.

> On the decibel scale, zero is an arbitrary level corresponding to the threshold of hearing for the average person. A rise of ten decibels corresponds to a tenfold increase in sound energy level, which is perceived as a doubling in loudness.

[28] Gilliland, Martha W., "Energy Analysis and Public Policy," *Science*, vol. 189 (September 26, 1975), p. 1056.

[29] Paul Sarnoff, *The New York Times Encyclopedic Dictionary of the Environment* (New York: Quadrangle Books, 1971), p. 234.

The following table lists some typical sounds and their decibel values.[30]

	db
House party, 4-piece rock band	115
Pneumatic hammer, 6 ft away	108
Walking near a helicopter	104
Outside, jet taking off at airport	102
Train stopping in station	100
Pushing a power lawn mower	96
At a seat in subway, windows open	95
Inside a jet airplane on take-off	94
Screaming child	92
Sports car running in street	86
Garbage truck, 200 ft away	85
Inside a city bus	85
Traffic at a residential intersection	82
Large office	60

Long-term exposure to noise levels above 80 dB may cause hearing impairment; at about 130 to 140 dB, noise will become painful.

Noise pollution can be abated by quieting the source itself, enclosing the source, isolating or damping vibrations caused by the source, absorbing the noise in soundproofing materials, and protecting persons with ear protection devices.

Normative

This important adjective encompasses all values, value orientations, and value-motivated activities. In contradistinction to the scientific method, which aspires to be value-free, any normative procedure or activity concentrates on the assigning of social values. It is the distinction made by Hume between "is" and "ought". Thus, normative forecasting of technology represents an attempt to identify what kinds of innovation will be needed (i.e., what society will desire or ought to have) by some future date. Normative analysis attempts to determine what is good or bad; science characterizes what happens and why. (See Forecasting, Normative.)

Objective (adjective)

Rational and unbiased; conducted, as research and analysis, in conformance with the canons of the scientific method (cf. Research). Not contaminated by normative values or emotional associations. An advantage commonly ascribed to Objective knowledge is that it is cumulative, and can be integrated into structures of rational association. No such claim is made for subjective knowledge.

Objective (noun)

An end or goal toward which efforts are directed.

Obligations

Commitments assumed by an agency under an authorization to be supported by a future appropriation.

[30] Migdon Segal, *Noise Control Legislation* (Revised) CRS Report 72–190–SP (Washington : Library of Congress, Aug. 29, 1972), p. 2.

Operations Research

"An experimental and applied science [q.v.] devoted to observing, understanding, and predicting the behavior of purposeful man-machine system."[31] The discipline of Operations Research is inherently pragmatic; its techniques are specific to the environment, the problem, and the use of the product. However, the method is that of Science (q.v.). A distinction can be made between Operations Research and Technology Assessment (q.v.) in that the former seeks to achieve Optimization (q.v.) of the measurable parameters of the system, while the latter consists of an evaluation of all consequences, to the extent feasible, in order to formulate public policy concerning the management and control of the system to satisfy broad criteria of the public interest. Characteristically, Operations Research relies extensively upon quantitative mathematical methods.

A tendency is noted to confuse Operations Research as the generalized use of quantitative methods of analysis with the specific use of some methodology enjoying a particular vogue. For example, linear program(m)ing, game theory, and queuing theory are all leading candidates. However, Operations Research encompasses all of these and many others besides.

As defined by Lord Rothschild, Operational Research is "the application of objective and quantitative criteria to decision-making previously tackled by experience, intuition, or prejudice. Called operations research in the U.S.A." It is, he notes, a subdivision of Applied Research (see Research, Applied).

Optimization

A system concept under which significant properties are identified as desirable or undesirable, and a determination made as to what quantitative level of each represents the best balance of total performance under a given set of constraints.

Option(s)

A choice among alternatives. In Technology Assessment, Policy Analysis, and PPBS (q.v.) such options are characterized as fully as possible in quantitative terms—as to their costs and benefits, including important second-order consequences—in order to establish a basis to aid in making rational management decisions.

A respondent suggests that too much stress may here be put on the quantitative aspect of Option Analysis (q.v.) Some technical issues defy quantification, such as for example, how much resources to devote to basic research or how to allocate between two claimant disciplines. Moreover, options may involve normative values that are not subject to quantification at all, yet may be brought into the assessment process, such as for example, impairment of scenic values, public apprehension of physical hazard, or convenience of the consumer.

Option Analysis

Both terms of this title are separately defined. Together, they refer to one of the functional elements of Program Evaluation or of Fu-

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[31] "Operations Research," *The Journal of the Operations Research Society of America*, vol. 19, No. 5 (September 1971), p. 1138.

tures Research and Policy Analysis (q.v.) by which the comparative merit of an alternative way of achieving a program objective can be determined and the alternative assigned the requisite resources. The analysis can be of a single alternative, or a comparison of several.

Paradigm

A set of relationships like a model, but more abstract and less quantitatively defined than a model. Thomas Kuhn defines paradigms as "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners."[32] Ayres defines it as "a structured set of axioms, assumptions, concepts, hypotheses, models, and theories, e.g., Newtonian physics or Marxist economics."[33]

Parameter(s) (also, Parametric)

A quantity or characteristic having fixed values for a particular subject for separately indicated cases or conditions. For example, the strength or resistance to failure of a given material (one parameter) will vary according to temperature (another parameter). The information can be presented in the form of a table or a curve.

Mathematically speaking, parameters are those factors, generally variables, which together represent or approximate the nature, functioning, or behavior of a system. For example, parameters which completely define a straight line in a Cartesian system are distance along the x-axis, distance along the y-axis, and the point at which the line crosses the y-axis.

Parameters are generally quantifiable and, when quantified, subject to mathematical formulation. However, the term may be loosely applied to factors which are not readily subject to mathematical operations. For example, parameters required to predict the outcomes of elections may include numbers of registered voters, party affiliations, past voter turn-outs, voter attitudes, expected impacts or major issues, and expected impacts of major interest groups, several of which are non-exclusive and non-quantifiable.

When parameters are quantifiable, or at least subject to analysis in qualitative form (like "popular" or "unpopular" candidates or "important" or "unimportant" issues), but not reducible to mathematical formulation (that is, not reducible to a statement of equality or nonequality), they may be analyzed in other ways. Such "Parametric" analyses include rank orderings, frequency distributions, graphic analyses, Cross Impact Matrix Analyses (q.v.), Algorithms (q.v.), Delphi Methods (q.v.), and heuristic modeling.

For a discussion of analysis conducted on the basis of unquantifiable parameters, but known mathematical relationships, see Parametric Analysis.

Parametric Analysis

An analysis conducted with assumed instead of expected or actual values. Such an analysis attempts to answer the hypothetical question :

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[32] Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: The University of Chicago Press, 1962), p. x.

[33] Robert U. Ayres, *Technological Forecasting and Long-Range Planning* (New York: McGraw-Hill Book Co., 1969), p. xiii.

if the values of the parameters were as assumed, what would the results be? Parametric analyses are used, in the absence of data from experiments or other sources, to examine a problem, to identify sensitive parameters, and to obtain reasonable approximations (on the high and low side) of final results. In a parametric analysis, a range of values for each parameter is assumed which will bracket the expected values for that parameter, and a solution is obtained to the problem for each set of assumed parametric values.[34]

See also Sensitivity Analysis.

Peer Review

A procedure customarily employed by Basic Scientists. It entails the formal examination of papers, reports, or findings of one scientist by others working in the same field (and presumed of comparable competence in the field) before they are accepted for publication, announced in journals, or presented at scientific meetings. (However, on occasion the presentation at scientific meetings is regarded as a form of Peer Review.) The same arrangement is used by the National Science Foundation to evaluate proposed research projects before allocating funds to support such projects.

PERT (Program Evaluation and Review Technique)

Various systems of management control and planning, amenable to computer application, for concentrating on critical elements in the design and construction of large structures or systems. The concept involves the identification of significant actions or accomplishments, the identification of actions that must precede these, the estimating of the time required to accomplish each, and the presentation of this information graphically (PERT chart) and as a computer print-out. The scheme strengthens management in numerous ways, such as by enabling flexible scheduling, identification of long lead-time items or tasks, and calling attention to problems needing correction. It speeds the process by showing the "critical path" to completion, and identifying the sequence of events that must take place so that management attention can be focused on them. A related technique, stressing this feature is CPM (critical path method). Another, stressing the economic aspects, is known as "PERT-Cost Method".

Photosynthesis

Photosynthesis is defined in the *McGraw Hill Dictionary of Scientific and Technical Terms* as: synthesis of chemical compounds in light, especially the manufacture of organic compounds (primarily carbohydrates) from carbon dioxide and a hydrogen source (such as water), with simultaneous liberation of oxygen, by chlorophyll-containing plant cells.

Plasma

Plasmas, often called the fourth state of matter, are highly ionized gases which are formed at very high temperatures (over 5,000° C.). They are composed of nearly equal numbers of positively charged

[34] Heymont et al., "Guide for Reviewers of Studies Containing Cost-Effectiveness Analysis."

nuclei and electronics. Plasmas are important because (1) most of the matter in the universe is in the plasma state, (2) they are the fundamental media of Magnetohydrodynamics (q.v.), and (3) they are part of many gas discharge and ultra-high temperature processes, and controlled nuclear fusion.

The word "plasma" also refers to the liquid part of blood or lymph, as distinguished from the corpuscles. It can be separated from the rest of the blood by centrifugation.

Policy (Collective Noun, also Policies)

A general course or method of operation adopted or proposed for the achievement or maintenance of a condition or (less frequently) the winning of an objective or for the minimization of error in the purposeful control of future events. The term is customarily employed with respect to social, public, administrative, and business institutions, and particularly to characterize the general principles guiding the operational decisions of their principal executives, to achieve coherence and consistency of management.

"Policy means . . . intelligently directed action toward consciously determined goals—as distinct from aimless drift and blind faith."[35]

A respondent suggests that an administrative hierarchy of procedure should be identified. It begins with Policy (as defined above), leading to Program ("an ordered set of interrelated actions"). Program, in turn, may be further subdivided into Projects or tasks, each contributing coherently to a Program in support of a Policy.

Policy Analysis

Cf. Policy Science(s) and Analysis. See also Normative. Generally, the analysis of policy calls for an investigation of cause and effect relations of policy alternatives in order to identify at the earliest possible point in time the preferred broad course of action to be taken by an agency toward its mission.

Viewing Policy as the complex of principles that govern action toward given ends, Policy Analysis includes such matters as the examination of the adjudication of laws, statements of leaders, agency documents, legislation and laws, and position papers from the private sector, for the purposes of evaluating goals, means, processes, objectives, achievements, and intentions; it seeks from this analysis to formulate guidance for management of government programs, use of resources, and control of human behavior. The analysis of policy encompasses: conflicts among policies, internal consistencies, impacts on society and its environment, political and organizational aspects, problems of coordination, determining of relative priorities, timetables for action in programming, and evaluation and overview requirements.

Yehezkel Dror has defined Policy Analysis as "an approach and methodology for design and identification of preferable alternatives in respect to complex policy issues. Policy analysis provides heuristic aid to better policymaking, without any presumption to provide optimization algorithms."[36]

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[35] "Resources for Freedom." A Report to the President by the President's Materials Policy Commission (Washington, D.C.: U.S. Government Printing Office, June 1952), p. 17; (The Paley Commission).

[36] Yehezkel Dror, *Ventures in Policy Sciences* (New York: American Elsevier Publishing Co., Inc., 1971), p. 3.

Policy Science(s)

(In this usage, Science(s) is the noun and Policy the adjective.)

Both Science and Policy are separately defined (q.v.). In general, Policy Sciences can be derived from the coupling of these two definitions. However, the term is relatively new, and subject to considerable interpretation. It appears mainly to encompass (1) an understanding of the process by which are evolved broad principles useful in institutional problem-solving activities, and (2) the kinds of knowledge (both scientific disciplines and value systems) useful in the application of the process to particular conditions, circumstances, or problems. According to Lasswell,[37] "The policy sciences may be conceived as knowledge *of* the policy process and of the relevance of knowledge *in* the process." Later on in this reference, he explains that the field is "contextual" and "problem-oriented." It appears also to be an attempt to introduce normative values into the decision process in a systematic way.[38]

Pollution

The concept of Pollution involves changes affecting the quality of life or resources. Usually, the term implies a judgment of degradation.

The President's Science Advisory Committee in its report *Restoring the Quality of Our Environment* (1965), stressed pollution as the undesirable consequences of man's activities: "Environmental pollution is the unfavorable alteration of our surroundings wholly or largely as a by-product of man's actions, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution and abundances of organisms."

The National Academy of Science's report *Waste Management and Control* (1966), also defined pollution as change having undesirable consequences: "Pollution is the undesirable change in the physical, chemical or biological characteristics of our air, land, and water that may or will harmfully affect human life or that of other desirable species, our industrial processes, living conditions, and cultural assets; or that may or will waste or deteriorate our raw material resources."

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92–500), however, defined pollution as any man-induced change and did not imply a judgment on the change: "The term 'pollution' means the man-made or man-induced alteration of the natural chemical, physical, biological, and radiological integrity of water"—or land or air.

The PSAC and Senate definitions refer to man-caused changes, while the NAS definition includes any undesirable change; the PSAC

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[37] Harold D. Lasswell, "The Emerging Conception of the Policy Sciences," *Policy Sciences*, vol. 1, No. 1 (Spring 1970), p. 3.

[38] According to E. S. Quade:

"During the past thirty years, almost a revolution has occurred in basic thinking about the nature of policy and how it is, or should be, made. The philosophies, procedures, techniques, and tools of the management and decision sciences—operations research, systems analysis, simulation, 'war' gaming, game theory, policy analysis, program budgeting, and linear programming, to name a few—are accepted in business, in industry, in defense, have started to penetrate the domestic political scene, and are even reaching into foreign affairs, that last bastion of the pure intuitionists. But, in those areas where policy is made for the public, this revolution is having heavy going and may soon run against a stop: the need from one point of view, to bring the knowledge and procedures embedded in the 'soft' or behaviorial sciences into systems engineering and aerospace technology and, from the other, to introduce the quantitative methods of systems analysis and operations research into the normal approaches by social and political sciences. * * * Hence the policy sciences—an interdisciplinary activity that attempts to blend the decision with the behavioral sciences". "Why Policy Sciences," *Ibid.*, p. 1.

and NAS definitions refer to "unfavorable" and "undesirable" changes, while the Senate definition refers to all man-made changes. All three see pollution as being alterations, but they differ in how they evaluate those changes and in what aspects the changes are pollution. What is a pollutant and pollution depends to some extent on one's point of view: heat can be a water pollutant or a source of warmed irrigation water; solid wastes can be viewed as a disposal problem or as source of raw materials. Clearly, the concept of pollution is affected by the perceiver's view of the potential pollutant and what benefits and damages it may cause. These variations make the judgments on pollution variable over time, among societies.

Different disciplines view pollution from their own perspectives. To a biologist, pollution is likely to be changes affecting the lives of organisms. To a sociologist, pollution may be a behavioral issue. To an economist, pollution is a problem in the allocation of costs.

Because of these variations, the student of science policy will need to indicate, when he speaks of pollution, whether he is distinguishing man-made from natural pollution and the degree to which he is basing his definition on a value judgment.

Population Science

Population research comprises studies of the nature, determinants, and consequences of population characteristics and dynamics and the development of basic data and methods for such population analyses. Physical, biological, psychological, cultural, social, economic, geographic, historical, and political factors may all be included in population studies. Operationally useful subdivisions of the field are:

a. Systematic *description* of population characteristics and dynamics including fertility, mortality, and migration; of geographic distribution and socio-economic composition; and of various correlates of different demographic rates.

b. Studies of the biological, psychological, social, and environmental *determinants* of population characteristics and dynamics, and of the effects of efforts to influence demographic rates.

c. Studies of the *consequences* of population characteristics and dynamics, at both personal and societal levels, with attention to technical, industrial, economic, political, psychological, social, environmental, educational, health, and related factors.[39]

Population science encompasses demography which may be defined as the statistical study of populations. Demography includes the study of population composition in terms of categories like births, deaths, migrations, age, sex, social status, ethnicity, income levels, marriage, divorce, illegitimacy, labor force, motivations, and survival rates.

Positive Feedback

See Feedback.

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[39] Office of Science and Technology, Executive Office of the President, *The Federal Program in Population Research*, pts. I and II. Report to the Ad Hoc Group on Population Research (Washington, D.C.: U.S. Government Printing Office, 1969), pp. 1101–1102.

PPBS (Planning-Programming-Budgeting System)

PPBS, a management system, was first introduced in the Department of Defense in the early 1960s. Conceptually. PPBS integrates planning, programming, and budgeting into an organization's decision-making process. Decisions on programs based on carefully articulated plans are made in light of the required resources. To arrive at these decisions plans are needed to translate agency goals into specific objectives, and programs are framed for each alternative method of achieving these objectives. Then budgets must reflect the total cost of each alternative. Decision-makers remain cognizant of these phases while judging effectiveness of performance versus cost.

Implicit in PPBS is the use of analytical tools. the first of which, operations research, grew out of problems arising during World War II. Operations research become a valuable tool in the war to solve tactical problems such as improving the effectiveness of anti-submarine and bombing operations. Systems engineering. cost-effectiveness analysis (or cost-benefit analysis), and the synthetic/analytic approach known as "systems analysis" were tools and techniques which closely followed behind the development of operations research.[40]

PPBS is a means. therefore, of analyzing both policy and the implementation of policy. a consideration of available alternatives and the resources that would be required by each. It is a means of resource allocations on a national scale, by overcoming the problems presented by the fact that requirements for programs are relative, clear criteria are wanting. and information as to the costs and benefits of alternatives is rarely available. Any individual program can plausibly demand resources beyond reasonable expectation of capacity to provide.

Herein lies the need for a new approach. While this allocation process is essentially a political one, it can be illuminated by the continuous assembling and analyzing of statistical data on the nature and capability of the economy and the objectives and needs of the Nation.

Program budgeting [i.e., PPBS] provides such an approach. It focuses on the decision-making process. particularly on the problems of data and analysis. Its first effort is simply the rational ordering of inputs and outputs. in which the initial emphasis is on the identifiable outputs—major objectives of Government processes. It then attempts to order the inputs—Government activities produced by manpower, material, real estate—so that comparisons among wide ranges of alternatives are feasible and meaningful.

[PPBS] starts with the structuring of the problem and ends with analysis of the data. Among the analytical tools. cost-benefit or cost-utility analysis that compares benefit or utility (outputs) with resources or costs (inputs) is a most prominent one. Since the objective is to improve the decision making that occurs in real life, and not in the philosopher's fancy, [PPBS] pays special attention to questions of organization and administration, and the politics and pressures of the workaday world.[41]

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[40] Robert L. Chartrand and Dennis W. Brezina, "The Planning-Programming-Budgeting System: An Annotated Bibliography," Multilith No. SP 114, Science Policy Research Division. Congressional Research Service, Library of Congress (Washington, D.C.: U.S. Government Printing Office. 1966), p. 1.

[41] David Novick. ed.. *Program Budgeting * * * Program Analysis and the Federal Budget* (Washington, D.C.: U.S. Government Printing Office. 1965), pp. xi–xii.

". . . The contribution of comprehensive planning, programming, and budgeting system is . . . in the conceptually simple yet operationally difficult task of (1) identifying the over-riding objectives of the organization; (2) developing an array of feasible alternatives for achieving them; (3) systematically choosing from among the alternatives; and (4) converting the results into operational decisions." [42] According to this author, the basic concepts of PPBS are as follows:

Planning.—The study of objectives, of alternative ways of achieving objectives, of future environments, and of contingencies and how to respond to them. The purpose of planning is to explore alternatives, to stimulate ideas about tradeoffs and management strategies, to identify problems, to formulate theories, and, of course, to generate data.

Programming.—A method or system of describing activities according to objectives or "outputs" . . . and of relating these objectives to the costs or "inputs" needed to produce the outputs.

Budgeting.—The activity through which funds are requested, appropriated, apportioned, and accounted for.[43]

Jay Mendell writes:

> *Planning* is the broad process of setting objectives and goals for the Department of Defense and its component parts, taking into account the current and projected world environment. These objectives and goals must, of course, be made in concert with national objectives. Generally, planning is concerned with what we want to do and can reasonably hope to achieve, whereas *programming* is the much more specific process of allocating resources among alternatives and appraising the benefits from alternative programs. Programming sets the level of effort and computes the consequent benefits in relative or absolute terms. *Budgeting* reckons the costs of programs. Thus budgeting concentrates on resource inputs, and programming on military outputs. The objective of PPBS is to link programming and budgeting like Siamese twins.

Later in his description he adds: "* * * The PPB System is premised on the assumption that when the Services compete for programs in the annual defense program *a decision can be made among alternatives on a rational basis, which includes a strong dose of systems analysis.*" [44]

Alice Rivlin writes:

> Despite its elaborate terminology, PPBS seems to me simply a commonsense approach to decision making. . . .
>
> The tools and the terminology may change, but the approach to decision making implicit in PPBS has largely, I think, been accepted in Washington, in principle if not always in practice. It is regarded as a desirable way to make decisions—if the time and information are available. Hardly anyone explicitly favors a return to muddling through.[45]

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[42] Statement of Murray L. Weidenbaum, Assistant Secretary of the Treasury of Economic Policy, June 2, 1970. *In* U.S. Congress, Joint Economic Committee, *Changing National Priorities*. Hearings before the Subcommittee on Economy in Government of the * * * June 2, 1970, pt. I. 91st Cong., 1st sess. (Washington, D.C.: U.S. Government Printing Office, 1970), p. 66.

[43] *Ibid.*, p. 64.

[44] Materials supplied in correspondence.

[45] Rivlin, Alice, *Systematic Thinking for Social Action* (Washington, D.C.: The Brookings Institution, 1971), p. 3.

See MBO (Management by Objectives) for a comparison of the major features of PPBS and MBO.

Prediction

Loosely, synonymous with Forecast (q.v.). Properly distinguished from it in that Prediction is a declaration (a non-probabilistic statement at an absolute confidence level) that some specified event will occur at a specified future point in time, or within some time period.

Priorities

Any systematic methodology to put first things first. It is the systematic application of pertinent criteria to a set of Options (q.v.) in order to rank the options in a rational order of preference as claimants for a limiting resource. The limiting resource can be time, management attention, dollars, manpower, or other. The implication of a priority system is that not all programs can be undertaken at once, or with the same degree of completeness or expenditure of resources, and that therefore the resources must be reserved (allocated) in accordance with a set of rationally-determined preferences.

A distinction should be made between program priorities and normative priorities. In the former, the limiting resource is material and quantitative; in the latter it may be a finding based on social attitudes. Ultimately, of course, physical limitations will prevail, even if they are insufficiently appreciated by society. Thus—

> Calling for a reallocation of national priorities is now a standard theme in the rhetoric of both the establishment and the student activists. What is often forgotten is that the term "priority" implies a choice. To have more of one thing, we must give up something else. If we could achieve all our objectives simultaneously, there would be no need to set priorities, no need to make difficult choices. Reallocating national priorities, therefore, is a double-edged concept—it not only involves a decision about what we want most, it also involves a decision about what we want least.[46]

Much of the discussion in the area of Science Policy revolves around the issues of how much money should be provided for supporting research and development and how the total pie should be divided among the various disciplines and subject areas of science and technology. The search for improved criteria and an improved methodology to apply to this allocation problem is an important area of science policy research. (See A. Weinberg, *Minerva*. Vols. I (Winter 1963), and III (Autumn 1964).)

Problem Assessment

This term is used by the RANN (q.v.) Program of the National Science Foundation to signify an institutional operation that "defines and analyzes national issues in a total context to synthesize existing

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[46] Statement of Charles L. Schultze, senior fellow, the Brookings Institution, and Professor of Economics. University of Maryland, June 1, 1970, before the Subcommittee on Economy in Government, Joint Economic Committee, *Changing National Priorities*, pt. 1, p. 2.

knowledge and identify specific opportunities for research to beneficially enlighten the decisionmaking process."

PROCUREMENT

In its simplest form, Procurement is the buying of something. However, this process has become enormously ramified, as conducted by the Federal Government, especially when the item to be bought is a large, complicated, and costly structure that does not exist when it is ordered. The complexity of the procurement process is illustrated by the (1) Armed Services Procurement Regulation (q.v.) of the Department of Defense, running to several thick volumes, incorporating the many instructions of the Congress on policies, constraints, and operational procedures. There are also large procedural manuals, specifying hundreds of required reports, procedures, and functions, issued by agencies responsible for the procurement of large systems. These deal with such related matters as inspection, quality control, documentation, cost analysis, configuration management, training programs, maintainability, and the like.

PRODUCT EFFECTIVENESS

A general or staff engineering function, especially in large aerospace and system-oriented corporations, intended to optimize the Effectiveness (q.v.) of large systems. It encompasses such elements as design effectiveness, availability, reliability, value engineering, quality control, safety, maintainability, and the like. (Cf. Procurement.)

PROGRAM (noun)

A set of actions to implement an agency's mission, or a major part of the mission; also, a pattern of instructions to a computer.

PROGRAM (verb)

To formulate the plan of actions for an agency, or the instructions to a computer.

PROGRAM ANALYSIS

A loose term which includes Cost/Benefit Analysis, Risk/Benefit Analysis, Cost/Effectiveness, PERT, PPBS, Policy Analysis, Systems Analysis, and Operations Research (q.v.). See also Program and Analysis.

PROGRAM EVALUATION

As used interchangeably with the term "social program evaluation," denotes three types of social sciences research employed in Federal agencies. Based on a scheme first identified by Wholey, et al.,[47] they are:

(1) Assessment of program impact, to determine the "overall effectiveness of programs in meeting their objectives [and] to examine the validity of the objectives chosen to solve the problems to which the

[47] Joseph S. Wholey, et al, *Federal Evaluation Policy: Analyzing the Effects of Public Programs* (Washington, D.C.: The Urban Institute, 1970).

program is addressed. [This kind of evaluation provides] information for use in the policy formulation process. Ideally this evaluation takes the form of a comparison between a control group and an experimental group, with measurement before and after treatment in conformity with a rigorous research design. An example of this kind of evaluation * * * is the evaluation of the impact of HEW programs on migrant and seasonable farmworkers."

(2) Program strategy evaluation, to: "inform program managers of the relative effectiveness of different techniques or methods that can be used in producing desired results. [It] depends on definition and measurement of the appropriate environmental process, and output variables selected on the basis of suitable analytical models. The evaluation of the Follow-Through Program is an example * * *."

(3) Project evaluation, to assess the "effectiveness of a specific mechanism that has been designed to accomplish program objectives. [It] is often conducted as part of the administration of the program and is frequently performed by the agencies or by the project managers * * *." [48]

Proof of Concept

Proof of Concept is a NASA research method, now common to many research and development efforts, by which an advanced design or principle is tested for feasibility by means short of actual incorporation in a pre-production prototype or device.

The term characterizes that phase of development during which a concept is tested in a realistic operational environment. This phase usually follows laboratory tests during which the environment is simplified, and precedes the prototype phase during which the configuration is optimized.

For example, a wing design conceived for large commercial transport may be proven by scaling it down and flight testing it on a small jet fighter aircraft. Although no production designs are produced, all data necessary for a production version are produced at substantial savings in cost and time.

Public Interest

Until recently, public interest could be defined as "something in which the public, the community at large, has some pecuniary interest, or some interest by which their legal rights or liabilities are affected. It did not mean anything so narrow as mere curiosity, or as the interests of the particular localities, which may be affected by the matters in question." [49]

Since the early 1960s, however, the concept of the public interest has been given a broader, less well-defined meaning which includes (1) the public's *general* interest in such things as consumerism and environmentalism and (2) a rationale for an expansion of the Government's influence in business and private affairs, particularly through the quasi-judicial powers of administrative agencies.

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[48] Laurence E. Lynn, Jr. "Notes from HEW" *Evaluation* (Fall 1972), p. 24.
[49] *State v. Crockett*, 86 Oklahoma 124, 206, pp. 816, 817 as defined in *Black's Law Dictionary*, revised 4th edition (St. Paul, Minn.: West Publishing Co., 1968).

"Public interest" law firms and interest groups, like Ralph Nader's organizations and John Gardner's Common Cause, are an outgrowth of this movement.

See also Citizen Participation.

Public Interest Science

The role of the scientist as a government adviser has been described and studied in detail for the last few decades, but only in the past few years has literary attention begun to focus on the "social" or "public" advisory role of the scientist. Several scientists have expressed the conviction that their information and advice on specific projects have been disregarded or even kept secret by public officials, and that it is only by "going public" that scientists can contribute scientific information to corporate, agency, or congressional policy formulation. As one reviewer stated in his description of a book on public interest science:

> The authors argue against continuation of the confidential client relationship between adviser and the executive branch of the federal government, contending that the obligation of the adviser is not to the agency which pays him but to the larger public.[50]

The public interest science movement has spawned the growth of several groups organized to promote scientific critiques of public policy projects. These include the Scientists' Institute for Public Information and the Center for Science in the Public Interest. This movement has also led to some philosophical consideration of the "social responsibility of the scientist."

See also Citizen Participation.

Public Technology

See Technology, Public.

Quad

Because the Btu, an amount of heat required to raise the temperature of one pound of water one degree Fahrenheit, is a very small quantity of Energy (q.v.), large amounts are often expressed as exponentials of the Btu. Thus, 10^{15} (quadrillion) Btu are frequently useful units and are called Quads. The U.S. consumption of energy in 1974 was about 73 Quads.

Quality of Life

This term is perhaps indefinable. Nevertheless, it enjoys considerable currency in the modern world. Presidents Eisenhower, Johnson, and Nixon addressed themselves to the meaning of the term in formal messages to the Congress. Accordingly, some discussion of its possible range of meanings may be helpful, without in any way purporting to represent a formal definition.

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[50] Day, Samuel H., Jr., "From Carson to Nader: The Growth of Public Interest Science": A Review of *Advice and Dissent: Scientists in the Public Arena* by Joel Primack and Frank von Hippel, *Bulletin of the Atomic Scientists*, vol. 31 (February 1975), pp. 47–48.

Both the National Science Foundation and the Environmental Protection Agency are supporting considerable research on Quality of Life indicators and on the related issue of Social Indicators (q.v.). Current research efforts are aimed at developing typologies of objective (actual) and subjective (attitudinal) indicators of preferred social conditions. Some researchers are attempting to give absolute and relative value to these indicators so that they can weigh the relative importance of one condition to another, for use in policymaking purposes.[51] Recent research findings demonstrate significant differences between objective indicators of Quality of Life (primarily currently collected governmental statistics) and subjective indicators of Quality of Life (people's perceptions and attitudes about favorable conditions of Quality of Life). According to many researchers, this finding demonstrates the limitations of using currently collected data to portray social conditions and social change, especially in urban areas.[52]

The term appears to be compounded of opposites: concern for the present versus concern for the future; normative values versus physical or material considerations; a dynamic balance of conflict and cooperation; hope and gratification; freedom and responsibility. The attitude of the individual appears to have great importance: it involves a conviction that life has meaning and purpose, that the efforts of the individual have efficacy, and also that the individual is not alone but belongs to a group with shared hopes, beliefs, and efforts.

Below the level of abstraction implied in the previous paragraph is a collection of considerations expressed by President Johnson in his message of January 4, 1965, the "Great Society" message. The items he proposed were education, health, urban improvement, beauty rather than pollution of the environment, uplifting of lagging economic regions, elimination of crime, expanded political participation, encouragement of art and literature, and prevention of waste. Implicit, of course, in this statement was the preservation of peace abroad. Indeed, the general thrust of the concept of Quality of Life seems to imply aspects of personal and community existence which are in addition to the "primal" (C.P. Snow) values of food, clothing, shelter, and security.

A review of U.S. national goals over the years since the founding of the Republic suggests that there is a tendency for the people of this country to focus on some one general goal—usually the correction of a deficiency or blunting of a perceived threat. Examples are: win a war, end a depression, or reduce environmental pollution.

It is evident that no list of national objectives or qualities would be equally pertinent for all individuals or groups of society. Moreover, the more detailed the itemization of desired qualities, the less the agreement as to their priorities. Governmental agencies are continuing

[51] U.S. Environmental Protection Agency, Office of Research and Monitoring, *The Quality of Life Concept: A Potential New Tool for Decision-Makers* (Washington: U.S. Government Printing Office, 1973), 397 p.
Dalkey, Norman C., et al., *Studies in the Quality of Life: Delphi and Decision-Making* (Lexington: Lexington Books, 1972), 161 p.
Liu, Ben-Chieh, "Quality of Life Indicators: A Preliminary Investigation," *Social Indicators Research*, vol. 1, no. 2 (September 1974), pp. 187–208.
Andrews, Frank M. and Stephen B. Withey, "Developing Measures of Perceived Life Quality: Results from Several National Surveys," *Social Indicators Research*, vol. 1, no. 1 (May 1974), pp. 1–26.

[52] Schneider, Mark, "The Quality of Life in Large American Cities: Objective and Subjective Social Indicators," *Social Indicators Research*, vol. 1, no. 4 (March 1975), pp. 495–510.

to support research on the topic but, as of now, the quest for a definition of Quality of Life appears to resolve into a determination by each individual for himself. In this context the phrase "pursuit of happiness" in the Declaration of Independence is pertinent. There may be some degree of consensus that there is such a thing as "Quality of Life" but no agreement as to how it is to be defined.[53]

Quick Fix (Also, Technological Quick Fix)

A prompt engineering action to correct a defect in a system, employing "off-the-shelf" hardware or designs already available, or an already-established alternative process not requiring validation.

RANN (Research Applied to National Needs)

A program of the National Science Foundation "to bring important new resources to the national effort to improve the quality of life." (q.v.) The program consists of support for a variety of problem-oriented research projects, including energy resource, conversion, and system activities; environmental activities like weather modification; productivity activities including public technology and economic productivity; and exploratory research and problem assessment activities including technology assessment. Criteria of acceptable projects are: *importance* (potential or actual significance and urgency to the nation), *payoff* (high domestic economic and social benefits), *leverage* (role of science and technology is significant), *readiness* (timely), *capability* (organizational resources available), *Need for Federal Action* (market incentive inoperative), and *Unique Position of NSF*.[54]

RDT&E (Research, Development, Testing, and Engineering)

An abbreviation used primarily in the management of the development of military hardware; it covers the spectrum of basic research, applied research, and development—including the design and development of prototypes. It extends from initial determination of a strategic requirement for a system with defined performance capabilities to the operational deployment of the system. A respondent supplies five definitions for terms that he suggests constitute the component elements of RDT&E, as follows:

> *Research:* Defense research is scientific study and experimentation directed toward increasing knowledge and understanding in * * * fields * * * related to long-term national security needs. It provides fundamental knowledge for the solution of identified military problems. It also provides part of the base for subsequent exploratory and advanced developments in Defense-related technologies and of new or improved military functional capabilities * * *.
>
> *Exploratory Development:* Includes all effort directed toward the solution of specific military problems, short of major development projects, with a view to developing and

[53] See Huddle, "The Evolution and Dynamics of National Goals in the United States," op. cit.
[54] National Science Foundation, *Justification of Estimates of Appropriations, fiscal year 1972* (Washington, D.C.: U.S. Government Printing Office, 1971), pp. D-17 to D-19.

evaluating the technical feasibility of proposed solutions and determining their parameters. This type of effort may vary from fairly fundamental applied research to quite sophisticated breadboard hardware, study and programming, and planning efforts.

Advanced Development: Includes all projects that have moved into the development of hardware for experimental test [to provide] proof of suitability of equipment, rather than the development of hardware for service use.

Engineering Development: Includes development programs in which the item is being engineered for service use but has not yet been approved for procurement or operation [but which] are initiated only in response to an approved military need.

Operational System Development: Includes R&D efforts directed toward the development, engineering, and testing of systems, support programs, vehicles, and weapons that have been approved for production and service employment.

Recycling

In its most narrow sense, recycling of materials means the rescue of materials from disposal and their subsequent reuse in essentially the same form. Thus, the recycling of paper means the collection of wastepaper and the reprocessing of the recovered pulp into new paper; the recycling of glass bottles means the collection of used bottles and their reprocessing into new bottles. In practice, however, this narrow sense of the definition has been enlarged to include several additional meanings. One such meaning is reuse: stationery, for example, may be reused for additional writing, as in using the reverse side for scratch paper, or may be used for another purpose unrelated to writing, as when incorporated into building materials like insulation and hardboard. Another meaning concerns conversion of a waste material from its existing form into another form which is then useful, as in converting wastepaper to protein or compost. Still another meaning concerns the use of a material so as to consume its substance entirely, as in burning wastepaper for fuel. Strictly speaking, reuse, conversion, and consumption do not represent recycling, but all have popularly come to be included within the term. Thus, in the broadest sense, recycling is the creative management of a waste material so as to obtain the maximum additional value from it, in contrast with disposing of the material as solid waste at additional cost.

Cf. Materials Management.

Research

Loosely, any gathering of information. More precisely, the gathering, ordering, and analysis of information on a systematic basis in accordance with predetermined criteria. Scientific Research is Research conducted in accordance with the scientific method. Research is concerned with the acquisition of knowledge while development is concerned with the systematic use of scientific knowledge directed toward the production of useful materials, devices, systems, or methods, including the design and improvement of prototypes and processes.

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According to the National Science Foundation, Research is "systematic, intensive study directed toward fuller scientific knowledge of the subject studied."

In an article in Nature ("Forty-five Varieties of Research (and Development)," Oct. 13, 1972), Lord Rothschild cites "the number of different sorts of research and development there seemed to be and the confusion they caused, at any rate in the minds of some people." In his article he proposes "to help to remove the confusion." Then he presents a tabulation of 45 terms, of which six refer to "pure research," 33 to "applied research," two to "development," and five to "miscellaneous." In his analysis of these terms, he suggests that all research should be divided into two categories, of "pure" and "applied" research. His analysis of applied research is discussed in this Glossary under Research, Applied.

Rothschild identifies five synonyms for "pure research" as follows: basic science, fundamental research, pure basic research, basic research, and absolutely pure research. However, he urges the use of Pure Research as the preferred form. This he defines as "research done solely to increase knowledge, without any practical application in view."

Under "miscellaneous," Rothschild includes as terms for definition: self-chosen research, curiosity-oriented research, speculative research, and general research (surcharge). The first two terms are, he says, synonymous and too broad in scope to be useful. The second two are partial synonyms and have a specialized institutional significance which he judges not very useful. (They have to do with "research which may be pure or applied and which is not directly concerned with an applied research programme, though done by the same research group, organization, or laboratory.")

Research, Applied

Systematic application of information, systematically acquired and validated. In particular, Applied Research is the practical application of such knowledge or understanding for the purpose of meeting a recognized need to develop a capability, employing the methods and data of Science (q.v.). It is distinguished from Development (q.v.) in that it does not extend to the design or construction of working processes or hardware.

As used by the National Science Foundation, the term means:

> [Research directed] toward practical application of knowledge—it covers "research projects" which represent investigations directed to discovery of new scientific knowledge and which have specific commercial objectives with respect to either products or processes. By this definition, applied research in industry differs from basic research chiefly in terms of objectives of the reporting company.[55]

For a useful collection of essays on the subject, see *Applied Science and Technological Progress*, Report to the Committee on Science and

[55] National Science Foundation, *National Pattern of R. & D. Resources, 1953–71*, NSF 70–46 (1971), pp. 24–25.

Astronautics, U.S. House of Representatives, by the National Academy of Sciences, June 1967.

In his article (Cf. Research) on "Forty-five Varieties of Research (and Development)," Lord Rothschild identifies 33 different terms for Applied Research. He presents them in an introductory list, and then proceeds to evaluate them out of consideration.[56] Those that remain, all subsumed under "Applied Research" are defined as follows:

Strategic Research. Research undertaken to generate specific applied programs.

Product Research. A subdivision of applied research whose objective is a new or improved product.

Process Research. A subdivision of applied research whose objective is a new or improved process.

Operational Research. The application of objective and quantitative criteria to decisionmaking previously tackled by experience, intuition, or prejudice. Called operations research in the U.S.A. A subdivision of Applied Research.

Research, Basic

The systematic acquisition and validation of structured information or knowledge about the universe, employing for the purpose the methods and assumptions of Science (q.v.). In particular, Basic Research is directed toward a fuller knowledge or understanding of the subject under study, rather than toward the practical application of the knowledge or understanding. One view of this activity stresses that its motivation is curiosity about nature, leading the practitioner "to proceed along sophisticated disciplinary lines as delineated by peer judgment as to the frontier problem areas." Moreover, "open and free dissemination of the results of such inquiries is an international tradition of the [basic] scientific community."

According to the National Science Foundation, "the definition of basic research stresses that it is directed toward increases of knowledge in science with * * * the primary aim of the investigator * * * a fuller knowledge or understanding of the subject under study, rather than a practical application thereof." NSF also notes that some research conducted by private industry may represent "original investigations for the advancement of scientific knowledge * * * which do not have specific commercial objectives, although they may be in fields of present or potential interest to the reporting company." This concept appears to relate to the discussion in the Glossary under "Research, Fundamental."

For a useful collection of essays bearing on Basic Science, see *Basic Research and National Goals.* Report to the Committee on Science and Astronautics, U.S. House of Representatives, by the National Academy of Sciences (March 1965).

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[56] His list includes: absolutely applied research, commissioned research, mission-oriented research, objective-oriented research and development, orientated [U.S. oriented] research, product-oriented reseach, tactical science, taget research, applied (project) research, applied (operational) [U.S. operations] research, short-term "troubleshooting" research, exploratory research, product research, process research, method of operation research, operational [U.S. opeations] research, strategic research, objective basic research, basic strategic research, target basic research, targeted basic research, basic applied research, applied basic research, strategic applied research, oriented-strategic research, and underlying research.

Research Exploratory

This category of investigation may be thought of as an intermediate stage between basic and applied research. Administratively, exploratory research is defined as "the early stages of research in areas not yet well enough defined or understood to merit full programmatic support." [57]

Research, Fundamental

"The search for new knowledge in a broad but definite scientific field without reference to specific applications."

Typically it involves inquiries—frequently multidisciplinary—into such natural phenomena as elasticity of polymers, catalysts, nuclear particle attraction, or the detonation process. Fundamental research is not—like so called "pure" research—the pursuit of knowledge for its own sake. Fundamental research seeks knowledge which will hopefully benefit someone someday. But the specific nature of its eventual application is not known at the time the research is performed.[58]

In many cases, Fundamental Research cannot be distinguished from Applied Research, (see Research, Applied) except by reference to the institution which conducts it.

Research, Interdisciplinary

Broadly, scientific research directed toward an objective or mission, involving practitioners of a number of relevant scientific disciplines. Various characteristics that distinguish Interdisciplinary Research from traditional single-discipline research include: multiplicity of disciplines, use of tools or findings of several disciplines, mission orientation, and organizational setting.[59] These may be discussed as follows:

a. *Disciplinary mix:* Donald J. Cunningham defines interdisciplinary research as research done jointly by social scientists with other scientists: "research which is conducted by a mixture of investigators gathered both from the disciplines of the physical and social sciences." [60] Another definition is: when investigation incorporates the finding tools and techniques of several disciplines, and particularly when it makes conceptual patterns and analyses pertaining to several branches of knowledge.[61] The distinction between single discipline and interdisciplinary research is lost when research using the techniques of several disciplines becomes institutionalized as a new scientific speciality,[62] such as biochemistry, astrophysics, urban affairs, or science policy. Indicators of institutionalization of interdisciplinary research as

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[57] National Science Foundation, "Exploratory Research and Problem Assessment (ERPA), mimeograph, p. 3.

[58] James Brian Quin and Robert M. Cavanaugh, "Fundamental Research Can Be Planned," *Harvard Business Review* (January-February 1964), p. 112.

[59] Based on: U.S. Congress, House, Committee on Science and Astronautics "Interdisciplinary Research—An Exploration of Public Policy Issues," Science Policy Research Division, Legislative Reference Service, Library of Congress, 91st Cong., 2d sess. (Washington, D.C.: U.S. Government Printing Office, 1970), 106 p.

[60] Dr. D. J. Cunningham, *Federal Support and Stimulation of Interdisciplinary Research in Universities* (Oxford, Ohio: Miami University, October 1969), p. 3.

[61] Pierre de Bie, "The Concept of Problem-Focused Research," *International Social Science Journal*, vol. XX, No. 2 (1968), pp. 204–07.

[62] Warren O. Hagstrom, *The Scientific Community* (New York, Basic Books, Inc., 1965), p. 149.

a new scientific speciality include its publication of specialized journals, and the formation of scientific societies and teaching departments.

b. *Applied or problem-oriented:* Interdisciplinary research is generally applied and problem oriented—designed to provide a solution or alternative solutions to important and complex problems at the interface of society and technology.

c. *Organization setting:* A variety of organizational forms characterize the conduct of interdisciplinary research. These differ from the units in which single discipline research is generally conducted. Typical of these organizations unique to the conduct of interdisciplinary research are: a university, interdisciplinary research problem institute; a non-profit non-academic research institute, frequently located close to both universities and industrial centers; Federal laboratory; social scientists teaching or working in professional schools, such as law, medicine, engineering, etc.; and a university interdisciplinary department or an *ad hoc* public policy advisory group established to assess research needs or particular social problems cutting across disciplinary lines.

An attempt is sometimes made to reserve the use of the term "Interdisciplinary" to combinations of the physical sciences (E.g. "Interdisciplinary Laboratories" sponsored by the National Science Foundation). According to this view, the definition given above would apply to the term Multidisciplinary Research.

Research Management

Research management includes the dynamic process of planning, organizing, leading, performing, administering, coordinating, and evaluating (1) scientific study; (2) experimentation; and, (3) for organizations in applied research, development, and production, the translation of that basic knowledge into new products, processes, and techniques.

"Different applications of the management process of planning, organizing, leading, doing, administering, coordinating and evaluating exist within many companies, according to the "basicness" or "purity" of the research and development. If the research is basic or "pure," the management process is applied to the basic research least, with more freedom, relief from routine, less punching of time clocks, more confidence in his professional ability, more participation in matters in which he is concerned, more choice of projects or tasks by him—and, in general, more democratic management and administration. The manager was found to apply fewer or less drastic controls because of the uncertainty involved, the relative lack of knowing where basic research is going (or how to do it), the greater degree of creativity involved, and the administrator's inability to tell the scientist what to do.

"The objective of basic research is more vague. The methods are less clearly defined, so that control cannot be as rigorously established. As research becomes applied to development and production, the objective can often be defined more clearly. In applied research, the goals of the

new scientific knowledge are related more to the specific commercial objectives with respect to either products or processes. The greater the relation to the specific products or process that can be made, the more objective and exacting can be the management and administration—especially the control, organization, the planning, the goals, and purposes.

"The management of development, then, is even more objective in translating research findings or other general scientific knowledge into products or processes. Development can be managed, administered and controlled more definitely than basic or applied research. And thus, as the results of development go into production, definite products are produced and more definite planning and control can be managed." [63]

Research, Mission-Oriented (or, Mission-Oriented Science)

Loosely, any Applied Research (see Research, Applied) although it may also be used to cover certain basic research activities (or activities in "Fundamental Science") deemed pertinent. The term is particularly associated with scientific research to provide information or capabilities needed to support the development of a system or to support a program. In other words, "Mission-Oriented" signifies that the research is directed and constrained by the goals and rules of some organizational entity and its mission.

According to one respondent, the term "fast-transit research" is sometimes used in Europe as synonymous with Mission Oriented Research, implying that the results of the research should be rapidly applicable to improve the efficiency of civil or military systems.

Research, Pure

Loosely, a term synonymous with Basic Research or Fundamental Research (see Research, Basic and Research, Fundamental). There is a tendency to associate the term Pure Research with the exclusive intent to expand knowledge and understanding of the physical universe.

Reserve

Reserves are that portion of identified material resources from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term "ore" is also used for reserves of some minerals. See Resource(s) for the relationship of Reserves to other currently or potentially available materials.

Resource(s)

In general, resources encompass all means or potential means toward ends or potential ends. They can include physical inputs, people (and their levels of training), information, institutional arrangements, available financial assets and credit, etc.

Resources may be tangible or intangible (e.g. beautiful scenery) and may be either valued or treated as free goods (e.g. air).

New definitions for mineral Resources have recently been adopted

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[63] J. F. Walters, *Research Management: Principles and Practice* (Washington, D.C.: Spartan Books, 1965), pp. 6–7 and 15–16.

by the Bureau of Mines and the Geological Survey of the U.S. Department of the Interior.[64] The present definitions are based upon two criteria: the extent of geologic knowledge about the resource and the economic feasibility of its recovery. These definitions include:

Resource: a concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible. Resources are of two types—*identified resources* and *undiscovered resources.*

1. *Identified Resources:* specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category. Identified resources are of two types—*reserves* and *identified subeconomic resources.*
   1.a. *Reserves:* that portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term "ore" is also used for reserves of some minerals.
   1.b. *Identified Subeconomic Resources:* known deposits not now mineable economically.
2. *Undiscovered Resources:* unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory. Undiscovered resources are of two types—*hypothetical resources* and *speculative resources.*
   2.a. *Hypothetical Resources:* undiscovered materials that may reasonably be expected to exist in a known mining district under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a reserve or identified subeconomic resource.
   2.b. *Speculative Resources:* undiscovered materials that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as reserves or identified subeconomic resources.

Resource Recovery

A concept signifying the recovery, for additional use, of resources already utilized at least once. The term Resource (q.v.) is generally taken to include all kinds of material resources as well as energy resources which, if not recovered, would go to waste. Included, for example, is the conversion of municipal solid waste to useful purposes, as well as the thermal use of heated waste water effluent from nuclear power plants for the heating of offices and homes. Impetus was given to the concept by passage of the Resource Recovery Act of 1970 (Public Law 91–512) which aimed at shifting national solid waste manage-

[64] U.S. Department of the Interior, *Mineral Resource Perspectives 1975*, Geological Survey Professional Paper 940 (Washington, D.C.: U.S. Government Printing Office, 1975), 24 p.

ment activities from disposal to recovery and reuse. Closely related is the concept of resource Conservation (q.v.), defined as the judicious use of resources to avoid their waste and prevent their premature depletion. Included within the concept is the more restricted concept of Recycling (q.v.). See also Materials Management.

RESOURCES, ALLOCATION OF (ALSO FEDERAL SUPPORT OF SCIENCE)

See Priorities.

RISK ANALYSIS

A respondent contributes the following comment on this term:

> This term is now becoming quite well established and an even more specialized term, "technological risk analysis," is used by the Department of Defense. The emphasis on risk analysis is due largely to the problem of overruns which have plagued large systems such as the C–5A and the F–111. The most important aspects in any commercial risk analysis involves two uncertainties: (a) market, and (b) cost of development and production. This kind of analysis is basically an effort or attempt to take specific account of these uncertainties rather than use "best estimates." In most cases, these uncertainties are in the form of subjective probability distributions. The outputs of such studies are probability distributions of quantities such as discounted cash flow return on investment, net present value, and net income. Thus, risk analysis provides the executive with answers to questions such as the following: What is the chance of loss on a project and what is the likelihood of achieving a 15% return on investment?

A related concept is "engineering risk," which is the degree of probability that a given design of a system, incorporating a number of components, will be effective. The design problem is to find the optimum trade-off between the use of proved components (thus inviting the risk of early obsolescence) and the use of wholly new and unproved components (thus inviting the risk of unreliability).

RISK/BENEFIT ANALYSIS (ALSO, BENEFIT/RISK ANALYSIS)

That portion of Cost/Benefit Analysis which pertains to the social costs of public health impacts of technology—such as deaths, disability, and discomfort. These elements of public risk are usually presented in mortality and morbidity statistics, but are most conveniently used in Risk/Benefit Analysis in the monetary terms of equivalent social costs.

A respondent notes: There has not always been an adequately comprehensive vantage point from which to consider the issues: very often, the risks are borne from a separate group from those for whom the benefits may accrue (i.e., the costs may be "external" to the undertaking). Furthermore, the risks are not always apparent "*a priori*."

SATISFICE (verb)

This is an activity of "administrative man" who looks for a course of action that is adequate, reasonably satisfactory, or "good enough." It may be contrasted with "maximize," an activity of "economic man"

who selects the best alternative from among those available. Examples of satisficing criteria familiar to businessmen are "share of the market," "adequate profit," and "fair price." A significant aspect of satisficing behavior is that administrative man, because he satisfices rather than maximizes, can make his choices without first examining all possible behavioral alternatives and without ascertaining that these are in fact all the alternatives.[65]

Scenario

The order or sequence of events, scenes, or situations. A methodology has been developed for analyzing alternative futures as "scenarios," by which a set of interacting forces (social, economic, political, technological, etc.) is assumed, characterized, and worked out in narrative form to a logical outcome. The purpose of the technique is to give a realistic, tangible illustration of the probable consequences of different policy options or goals. The term Scenario originated with the motion picture industry, to signify the story outline combined with descriptions of the kinds of pictures needed to help tell the story.

Science

This is a term for a broad area of human activity based on the unifying assumption of the universal relationship of effects to causes. It is aimed at discovering, characterizing, organizing, and explaining facts and relationships according to principles of systematic and logical thought. Characteristic of science is the method of developing and testing of hypotheses through empirical observation (inductive-deductive reasoning), the validation of findings through replication, the construction of orderly taxonomies of related information, and reliance on quantitative measurements employing accepted standards. Within the taxonomies of each scientific discipline, the scientific effort seeks to achieve progressively finer grain of detailed understanding; externally, each discipline of science seeks to establish relationships among classes of phenomena.[66]

The term Science is loosely applied to encompass not only the activity itself but also the community of practitioners of science (Scientists), who are also governed by the rules and constraints (canons) of science. The term also embraces the products of science, in the form of discovered factual information, laws, concepts, inventions, and even novel artifacts relying on scientific discoveries for their inception.[67]

As science encompasses both basic and applied activities, the practitioners of both categories of science are called Scientists. This combination of meanings should present no difficulty, however, as the shades of distinction between them in practice tend to be very fuzzy. On occasion, it is said, the workers in the same laboratory use the same equipment to perform the same operations at different times for differ-

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[65] From Herbert A. Simon, *Administrative Behavior* (New York: The Free Press, 1957), pp. xxiv and xxv.

[66] Louise B. Young and William J. Trainor, eds., "Science and Public Policy," prepared by American Foundation for Continuing Education at Syracuse University (Dobbs Ferry, N.Y.: Oceana Publications, Inc., 1971), pp. 3–48.

[67] Authorities to be consulted on various aspects of the subject would include C. P. Snow, *The Two Cultures, and a Second Look* (New York: Cambridge University Press, 1964), 100 p., describing the interface between the scientific community and the nonscientific community: Robert Merton in Bernard Barber and Walter Hirsch, eds., *The Sociology of Science* (New York: The Free Press of Glencoe, 1962), an investigation into the scientific sub-culture.

ent purposes, one of which is "basic research" and the other "applied research."

Science is sometimes described as a "value-free" activity, to suggest that it is normatively neutral in purpose and that the results of scientific discovery can be used for good or bad purposes. However, the canons of science are themselves normative values—for example, belief in the efficacy of rationality, respect for precise and careful procedure, and insistence on the free interchange of information.[68]

"Nature" as it really is and "science," the characterization of nature through disciplined study, are not synonymous. The distinction is important in Science Policy (q.v.) analysis, particularly in regard to the allocation of resources to conduct scientific research. According to Dr. Charles S. Sheldon: [69]

Science denotes "to know." By custom, human knowledge has been organized into disciplines, which are systematized, interrelated sets of accepted laws, probabilities, and hypotheses. Classification of knowledge into disciplines is not the way nature works; it is man's invention to help him understand more systematically the relationships within nature. Recognition of the imperfection of man's invention of the scientific disciplines has led to a proliferation among the disciplines, and to conjunctions among disciplines, to provide further categories of information produced by "interdisciplinary research." Actually, all investigation of the facts of nature must be interdisciplinary because no natural relationship can be observed by man within the constraints of a single, pure category of knowledge. The deeper any single scientific discipline penetrates into its own blocked out area of concern, the more it becomes involved with other disciplines. Nuclear physics looked to astronomy for demonstration of fusion; genetics consulted molecular chemistry for elucidation of genes; the study of plant propagation demands an understanding of electro-optics. Nature, in short, does not heed the disciplines man has invented.

One very real question is whether the large investment of public funds in basic disciplined scientific research, by being channeled into the artificial disciplines of science, is freezing in concrete as it were an obsolete and outworn structure of knowledge. Should we boldly attempt to restructure our disciplines? Should we give thought to the effect of public investment in possibly perpetuating an obsolete system of knowledge that may be obstructing our understanding and our quest for further understanding, even while they make convenient the imparting of what we know?

Science, Applied

See Research, Applied.

Science, Basic

See Research, Basic.

[68] For an attempt to couple normative values with national science policy, see Robert W. Lamson, "Framework of Categories for Science Policy Analysis and Technology Assessment," Office of Planning and Policy Studies, National Science Foundation, mimeograph (November 1969).

[69] Statement of Dr. Charles S. Sheldon, II, Science Policy Research Division, Library of Congress. *In* U.S. Congress, House. Committee on Science and Astronautics, Subcommittee on Science, Research, and Development, *National Science Policy*, H. Con. Res. 666, Hearings, 91st Congress, 2d Session, July 7, 8, 21, 22, 23, 28, 29; August 4, 5, 11, 12, 13; September 15, 16, 17, 1970. (Washington, D.C.: U.S. Government Printing Office, 1970), 670.

Science(s), Behavioral

See Science(s), Social.

Science, Fundamental

There is a tendency to associate the term Fundamental Science with integrative principles that shed light on several different scientific disciplines, thereby opening the way to many new discoveries in each. See also, Research, Fundamental.

Science Infrastructure

The institutions necessary for the support of scientific research but which neither perform research nor control it. They include the industries producing instruments, the institutions establishing scientific standards, the institutions and other arrangements for documentation, exchange of scientific communications, interpersonal contacts among scientists, and for the training of technical support personnel in skills required in the laboratory, such as glass-blowing, electronic circuitry, instrument calibration, and the like.

Science, International (Also, International Scientific Interactions)

As science and technology have become increasingly important to nations, the international issues have become highly significant. Furthermore, worldwide cooperation, beginning with the International Geophysical Year (1957) has provided opportunities for interaction and cooperation, and cost-sharing, which have been highly productive.

Both governmental (United Nations Organizations for Economic Cooperation and Development, etc.) and non-governmental (International Council of Scientific Unions, Committee on Space Research, etc.) organizations have provided mechanisms for cooperation. The organizational structure, personnel, activities, and results of this general field are loosely subsumed under the term "International Science."

Science(s), Life

The term Life Sciences encompasses a composite of highly specialized sub-unit scientific disciplines for the study and control of living organisms. "Molecule to man" in scope, it confronts questions and problems of life in: origin, heredity, evolution, structure and development; materials and their transformation processes; behavior, environment, and disease. A meaning increasingly influencing investigators in the Life Sciences, whether or not they designate themselves as "Ecologists" (see Ecology), is the interdependency of the living world; thus, problem solving in areas concerning food, population, renewable resources, health, and disease, involves understanding across the entire spectrum of living things.

The historical characteristics assigned to the term "Life" had to do with the readily visible properties of growth, structure, reproduction, mutation, and motility. However, since the advent of the electron microscope and molecular biology, living matter is now known to require

an extremely complex intracellular organization and a very large number of chemical processes. Although living organisms are more than the sum of their parts, the phenomenon of life is now understood in terms of the same chemical laws that govern and characterize the nonliving physical universe. It is here (i.e., the chemistry of life) that the revolution in biology is taking place, and where life scientists expect to achieve the next generation of advances in the quality of life for man and his fellow creatures.

Another revolution, just beginning in the life sciences, is the conservation of those environments and resources essential to the "chemistry of life." In matters of this type the life scientist (psychologist and sociologist) must deal with the behavior of man himself. The problem which confronts workers in these disciplines is that, among man's resources, humankind is the least manageable of all.

Science(s), Natural

Includes Physical Science(s) and Life Science(s) (see Science(s), Physical and Science(s), Life), but is generally taken to exclude the Social or Behavorial Sciences (see Science(s), Social).

Science(s), Physical

According to Merriam-Webster, Second Edition: "Any of the sciences included under the head of pure physics, or of the allied sciences, as chemistry, mineralogy, petrology, geology, astronomy, meteorology, etc." In essence, it encompasses the sciences dealing with inanimate matter, energy, and their related phenomena. It excludes the Social or Behavioral, and Life Sciences (q.v.).

However, according to a communication from a staff member of the National Science Foundation, the disciplines of mineralogy, geology, and meteorology are more properly Environmental Sciences than Physical Sciences. According to this view either they should be deleted from the definition or the term to be defined should read "Science(s), Physical and Environmental."

Science Policy

(In this usage, Policy is the noun and Science the adjective.)

The Brooks Report (cited below) observes that "Science policy is generally conceived of as a deliberate and coherent basis for national decisions influencing the investment, institutional structure, creativity, and utilization of scientific research." Its scope encompasses "the natural sciences (presumably including the life sciences), the social sciences, and technology."

In this Glossary, both Science and Policy are separately defined (q.v.). In general, Science Policy can be derived from the coupling of these two definitions. However, by usage, the term Science Policy has come to embrace, at the level of national government, two different social functions: (1) the political process affecting the activity of organizations engaged in science or in the training of scientists, and (2) the political decisions that select particular scientific activities for public support by virtue of their perceived potential contributions toward social or political goals. Both deal with the political process as a form of influence or control on the conduct of scientific activities.

According to the Brooks Study:

> In the first place, science policy means policy for the development of technology, as well as policy for science as ordinarily understood. It is concerned with the allocation of resources for scientific research and technical development. It includes government encouragement of science and technology as the roots of strategy for industrial development and economic growth; but it also includes the use of science in connection with problems of the public sector. Because of the close association of basic research with higher education, this aspect of science policy is difficult to separate from overall educational policy and from technical manpower policy.
>
> But science policy does not comprise only policy for science—that is, for the creation of an environment in which science can flourish and choices can be made among scientific and technological projects and fields; it also comprises science for policy—affecting the ways in which scientific and technical considerations bear on important political decisions and policy choices in areas that are not themselves mainly scientific, such as foreign affairs or urban planning. Indeed, some observers have even questioned whether it makes sense to conceive of science policy as a distinct and separate area of policy. Nevertheless, science, including the social sciences, penetrates deeply into almost every aspect of the government function, as indicated by the growing percentage of technical specialists in the upper levels of the civil service. It requires consideration in its entirety as a set of means to other goals, having some coherence within itself across the functions that it serves.[70]

With the increasing significance of science and technology for public interests and goals, there has arisen a large number of institutes, associations, and university programs investigating and publishing on this theme. (See D. Schooler, *Science, Scientists, and Public Policy*, New York, The Free Press, 1971.) Also, with the large sums provided to the scientific enterprise by the "public patron," there has been increasing attention to various aspects of science and government with regard to the methods of support, areas of support, institutions for support, etc. Both the legislative and executive branches of Government have been searching for answers to the various issues involved, and recently State and local government attention has been drawn to the issues. See U.S. Cong., House, Comm. on Science and Astronautics, *National Science Policy*, (H. Con. Res. 666), Hearings before the Subcom. on Science, Research, and Development, 91st Cong., 1st sess. (Washington, U.S. Government Printing Office, 1970).

Science(s), Social (Also, Behavioral Science(s))

"The objectives of basic and applied behavioral and social science are essentially the same as those of other sciences: the scientific method is used to establish a body of fact and theory, demonstrable and communicable, that contributes to knowledge and understanding that

[70] "Science, Growth, and Society," OECD, op. cit., pp. 37–38.

will permit man to manage his affairs with greater rationality."[71] The object of study is human behavior; differentiations are usually drawn along the following lines:

> The unit of analysis in behavioral science is the individual.
> The unit of analysis in social science is aggregates of individuals in formal and informal social groupings and institutions.

While biological scientists examine animate physiological and environmental factors which may effect changes in patterns of individual behavior, behavioral scientists (e.g., psychologists, anthropologists, and psychiatrists) focus upon inanimate mental factors or real or perceived environmental or social factors which cause patterns of behavior in the individual and groupings of indviduals as a consequence of social, cultural, economic, or political arrangements, beliefs, traditions, institutions and opportunities. Such social sciences include economics, sociology, political science, and history.

Scientific Method

See Science.

Scientific Proof

In the conduct of Science (q.v.), the product sought is knowledge. The problem is how to validate what is known. The convention adopted in the Scientific Method is to assume that all knowledge is probabilistic, so that certainty is never perfect. Scientific proof consists of the application of logical reasoning and quantitative factual evidence in order to reduce the probability of error as close to zero as possible.[72] Another way of stating this is that Scientific Proof attempts to marshal quantitative evidence in a logical demonstration to show the degree of certainty (e.g., by giving figures with an indication that they are accurate to plus or minus some numerical percent), and thus to indicate the degree of probability that a conclusion is valid. Replication of tests and verification of deduced effects of assumed principles raises the level of probability from hypotheses to "laws" of near certainty. Even so, it is a frequent event for laws to be overthrown or modified by further evidence.

Scientist

See Science.

Second-Order Effects (or Consequences)

See Side Effects.

Sensitivity Analysis

An analytical procedure to identify particularly sensitive responses of a system to changes in specific inputs or other factors. According to the Research Analysis Corporation, it is defined as follows:

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[71] "The Behavioral and Social Sciences: Outlook and Needs." A Report by the Behavioral and Social Sciences Survey Committee under the auspices of the Committee on Science and Public Policy. National Academy of Sciences, and the Committee on Problems and Policy, Social Science Research Council (Washington, D.C.: National Academy of Sciences 1969), p. 20.

[72] It is interesting to note the distinction between legal proof and Scientific Proof. Thus, a defendant can be convicted on testimony of a single individual witness, under conditions in which replication is impossible, even though the probability of human error of observation is high; but he cannot be convicted on the basis of a very high statistical probability that he conforms to be known facts about the criminal. The term "beyond peradventure of a doubt" is clearly unscientific.

Repetition of an analysis with different quantitative values for cost or operational assumptions or estimates such as hit-kill probabilities, activity rates, or R&D costs, in order to determine their effects for the purposes of comparison with the results of the basic analysis. If a small change in an assumption results in a proportionately or greater change in the results, then the results are said to be sensitive to that assumption or parameter.[73]

Serendipity

According to Merriam-Webster, second edition, "The gift of finding valuable or agreeable things not sought for; a word coined by Walpole [Horace, Fourth Earl of Oxford] in allusion to a tale, *The Three Princes of Serendip*, who in their travels were always discovering, by chance or sagacity, things they did not seek."

The analogy with basic, pure, and fundamental research is obvious. However, there is no obvious reason why the analogy should not also be applicable as well to applied research in all its various forms.

Side Effects (Also, Secondary Effects, Second-Order Consequences, Indirect Effects) (for Effects, Impacts Is Sometimes Used)

The purpose of all Technology (q.v.) is to improve the compatibility of man with his Environment (q.v.) in some explicit way.[74] However, it has been noted that technological innovations invariably produce other effects, unintended and often undesirable. These may be inherent in the innovation or they may result from its misuse. They may be immediate or long range, decisively important or minor, discrete or incremental or perhaps synergistic. They are usually related in impact to the extent of use of the technology from which the impact derives (cf. Diffusion of Technology).

Conceptually, the term involves two elements, an "effect" and the modifier suggesting that the effect in question is unmotivated and derivative.

From the comments received on this term, the impression is received that there exists some idea of an ordered structure of secondary effects (second-order, third-order, etc.) with time as perhaps another parameter. One respondent questioned, for example, the "merging of [Second-Order Effects] completely under Side Effects" and contended that the former "has a specific connotation involving cause-effect over time affecting increasingly abstract or complex levels of the culture" while Side Effects "can include specific and immediate effects, expected or not; usually, it just means they were unintended or deleterious." In the physical sciences, Second-Order Consequences conveys the idea of a chain of causality; thus, effect A produced by cause A becomes the cause of effect B which becomes the cause of effect C. In this sense, effect B is a secondary effect, and effect C is a tertiary effect. Also

[73] "Guide for Reviewers of Studies Containing Cost-Effectiveness Analysis," op. cit.

[74] This is the view of the author of the Glossary. It is not universally held. One respondent took scientific exception, holding that "the purpose is to satisfy man's needs desires." Another nonconcurring respondent suggested that the "definition should point out that some side effects may be purely social consequences (e.g., the effect of the automobile on the family, sexual morality, and religion)."

included in this concept is the idea that effect A may occur at once, but that effect B will occur later on, and effect C still later.

In the field of medicine and drugs, the term Side Effect means simply an unintended effect. Unfortunately for simplicity, the side effect of a drug developed for the treatment of Parkinson's disease may be discovered to affect male sexual activity and perhaps be prescribed for this effect, or a birth control pill may be prescribed as a hormonal treatment to correct skin blemishes. Thus, side effects are not necessarily undesired and, once characterized, may be converted into intended effects.

These are perhaps useful distinctions, but it is not clear that they are universally adhered to in Science Policy usage.

Simulation [75]

Use of a model, generally mathematical, to represent a real system for the purpose of gathering information about how it responds to changing conditions. Advantages of simulation are that (1) it is typically faster and cheaper to simulate reality than to exercise the real system and (2) simulation does not disturb the real system.

Normally, simulation is done on a digital computer because of the computer's speed and capacity to store information and instructions. However, simulation may be done by hand, with an analog computer, or by means of physical representation, the latter normally in miniature, like a wind tunnel.

Typical uses of simulation include aerospace systems; industrial and inventory systems; physiological, biological, psychological, and medical systems; many vehicular systems; political, economic, environmental, and social systems; physical science systems; and instructional systems.

Social Audit

Related to social accounting (cf. Social Indicators), but applied almost exclusively to social accounting in business firms. The general objectives of corporate social auditing are to identify, quantify in dollar terms, and draw up a balance sheet to measure the social responsibility of a corporation. According to Sethi, this information would be used to assist—

> institutions and groups through political process to assign relative weights and priorities to various elements of social responsibility, fix responsibility for overseeing performance, and assist existing and emerging * * * corporations to alter their *modus operandi* and goals to meet the new performance criteria thus established.[76]

The resulting balance sheet would also be used to compare the relative social responsibility of several firms.

There is little consensus on the components of a social audit, but widespread agreement that there are significant conceptual, methodological, and (input and output) measurement obstacles to the development of such a social audit.[77]

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[75] Adapted from information supplied by the Federal Simulation Center, Alexandria, Va.

[76] S. Prakash Sethi, "Getting a Handle on the Social Audit," *Business and Society Review/Innovation* (Winter 1972–73, No. 4), p. 33.

[77] Raymond A. Bauer and Dan H. Fenn, Jr., *The Corporate Social Audit* (New York: Russell Sage Foundation, 1972), 102 p. (Occasional Publications Reviewing New Fields for Social Science Development, No. 5); and ——. "What is a Corporate Social Audit?" *Harvard Business Review*, January–February 1973, pp. 37–48.

Two types of audits are discussed in the literature. First, a process, management-oriented, and exclusively internal, which inventories the corporation's explicit socially motivated goals and activities and relates them to objective performance criteria to assist the corporation in developing new goals and programs to meet observed deficiencies.[78] Fringe benefits given to employees for education might be included, for example.

A second type of audit, oriented to the external environment and usually publicly reported, would include those "activities that [a corporation] considers socially beneficial and that may be of interest to such groups as investors, consumers, public bodies, and the general public." [79] For instance, it might weigh the firm's tax contributions allocated for pollution control and its own pollution abatement efforts in comparison with costs incurred by the community in eliminating pollution caused by the firm.

Various combinations of these two types of social audits are being explored.

Social Costs

See Externalities (also, External Effects) and Risk/Benefit Analysis.

Social Indicators (Also, Social Accounting System)

In a seminal work on this subject, Professor Raymond A. Bauer described Social Indicators operationally as "statistics, statistical series, and all other forms of evidence that enable us to assess where we stand and are going with respect to our values and goals, and to evaluate specific programs and determine their impact." [80]

Subsequently, a definition prepared in the Department of Health, Education, and Welfare by M. Olson, emphasizing how social indicators would differ from currently collected statistics, read as follows:

> A social indicator * * * may be defined to be a statistic of direct normative interest which facilitates concise, comprehensive and balanced judgments about the condition of major aspects of a society. It is in all cases a direct measure of welfare and is subject to the interpretation that, if it changes in the "right" direction, while other things remain equal, things have gotten better, or people are "better off." Thus statistics on the number of doctors or policemen could not be social indicators whereas figures on health or crime rates could be.[81]

The H.E.W. definition has been modified on two counts: first, on the basis that to provide social guidance on action programs, a social indicator system should measure both inputs and outputs—in other words, both quantity of medical care and qualitative health conditions, which are measured against consensually accepted levels of health, health care, and health care delivery; and second, that indicators should describe quantitative changes in the qualitative components of a social system or an accepted explanatory model of a social system.

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[78] Bauer and Fenn, ibid.
[79] Sethi, op. cit., p. 34.
[80] Raymond A. Bauer, ed., *Social Indicators* (Cambridge, Mass.: M.I.T. Press, 1966), p. 1.
[81] U.S. Department of Health, Education, and Welfare, "Toward a Social Report" (Washington, D.C.: U.S. Government Printing Office, 1969).

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Conceptually, Social Indicators would be used for policy and program guidance in a way similar to the use of reports of the Council of Economic Advisers. One legislative proposal to provide such a system called for a Council of Social Advisers.

According to Kenneth C. Land of the Russell Sage Foundation, "three recurring claims for social indicators arising from the exigencies of public policy decisions are that social indicators can help (1) to evaluate specific programs, (2) to develop a balance sheet or system of social accounts, and (3) to set goals and priorities."

> I propose [continues Land] that the term *social indicators* refer to social statistics that (1) are components in a social system model (including sociopsychological, economic, demographic, and ecological) or of some particular segment or process thereof, (2) can be collected and analyzed at various times and accumulated into a time-series, and (3) can be aggregated or disaggregated to levels appropriate to the specifications of the model. Social system model means conceptions of social processes, whether formulated verbally, logically, mathematically, or in computer simulation form. The important point is that the criterion for classifying a social statistic as a social indicator is its *information value* which derives from its empirically verified nexus in a conceptualization of social process.[82]

National social indicators report have been published by several governments, including the United States, Japan, Great Britain, France, West Germany, Norway, and Canada, as well as by more than a dozen large U.S. cities.

Among Federal agencies which support social indicators research for applied purposes are the Departments of Health, Education and Welfare, especially the Office of Education; Housing and Urban Development, Agriculture; and the Agency for International Development.

The Division of Social Sciences of the National Science Foundation undoubtedly supports most federally sponsored basic and applied research on indicators. The NSF program has two main thrusts according to Murray Aborn, Program director for the Special Projects and Social Indicators Program:

> One cluster of projects has developed around the objective of trying to improve the quality and communicability of data likely to appear repeatedly in social reports. At present the support picture centers on several large multidisciplinary efforts such as:
>
> a. Social Graphics.
>
> b. Time Budget Surveys.
>
> c. [The Social Science Research Council's] Social Indicators Coordination Center.
>
> (1) Assistance with victimization surveys (Census Bureau)
>
> (2) Assistance with scientific standards for federally supported surveys of all types (OMB)

[82] Kenneth C. Land, "On the Definition of Social Indicators," *The American Sociologist*, vol. 6, No. 4 (November 1971), pp. 322–23.

(3) Assistance with the development of science indicators (National Science Board)

Another cluster of projects centers around research on integrated series of statistics within which indicators are identified and related to things other than themselves. At present, the support picture centers on several large multidisciplinary efforts such as:

a. Measures of Social and Economic Performance (extending the existing system of national accounts to introduce welfare as well as growth outcomes)

b. Goals Accounting (estimating the possibilities for social change by determining the costs of resource allocation among multiple societal objectives over fixed time periods)

c. Urban Indicators (ascertaining local-level policy needs as determined from models based upon the "consumption" rather than the "production" processes of human welfare. Jointly with HUD.) [83]

However, too much should not be expected of Social Indicators too soon. First, "the elusiveness of the concept * * * stems from the multitude of views about the relevance and purpose of developing and organizing statistics about the state of affairs of the country and its constituent parts." Second, "[some recent] literature in the social indicators field * * * testif[ies] not alone to the paucity of quantitative data on certain social conditions, but also to the lack of fit between the existing body of social statistics and the several purposes associated with the social indicators movement." [84]

Social Invention

Generally, a social or behavioral science advance, breakthrough, finding, or new technique (cf. Technology) which the social science community judges both theoretically founded (i.e. the causes and effects of the finding can be determined and explained), and also empirically validated, and which applied social practitioners or policymakers can use to effect changes in social behavior. A recent study of 62 major advances in applied social science since 1900 identifies as "Social Inventions" in economics: social welfare function; understanding of economic propensities; employment and fiscal policy; game theory; national income accounting; operations research and systems analysis; theories of economic development; econometrics; and cost-benefit analysis (planned programming and budgeting). In psychology: psychoanalysis and depth psychology; learning theory; intelligence tests; conditioned reflexes; Gestalt psychology; projective tests; operant conditioning and learning; teaching machines; and scaling theory. In sociology and political science: sociometry and sociograms; factor analysis; large-scale sampling in social research; attitude survey and opinion polling; content analysis;

[83] Letter to Genevieve Knezo from Murray Aborn, January 31, 1975.

[84] Dr. Henry David, Executive Secretary Division of Behavorial Sciences, National Academy of Sciences-National Research Council, "Social Indicators: Reverent and Irreverent Observations," prepared for the NATO Advanced Study Institute on Technology Assessment, La Garda, Italy, Sept. 18–29, 1972, draft version, p. 15.

multivariate analysis linked to social theory; computer simulation of social and political systems; conflict theory and variable sum games; stochastic models of social processes; and sociology of bureaucracy, culture, and values.[85]

Another study, citing instances of major social science studies which have impacted on public policy, lists among others: studies of social security legislation contributing to passage of the Social Security Act of 1935; studies of legislative behavior which led to passage of the Legislative Reorganization Acts of 1946 and 1970; studies of minority group problems and problems of blacks in America which led to Supreme Court decisions on civil rights during the '50s; political science studies on deterrence impacting on policy formulation in the Defense Department; sociological and anthropological studies of cultural variation which underlay formation of the Peace Corps; sociological studies of the state of the humanities in society which provided the basis for passage of legislation on the National Foundation for the Arts and Humanities; and studies of impacts of television on society and culture which in large part stimulated formation of public broadcasting.[86]

In the study, *Technical Information for Congress*, an illustrative sampling of important social inventions before 1945 is presented, as follows:

parliamentary procedure	retirement pensions
the Australian ballot	insurance
Federal-State grants-in-aid	mass public education
budgeting and accounting methods	institutional waste disposal
the census	public hygiene
Government corporations	statistical sampling and quality control
job and personnel classification	workmen's compensation and unemployment compensation
national income and product statistics	opinion polls
hospitals	institutional outpatient care
clinics	
work simplification surveys	

The relationship between these inventions of applied social science and the data, theories, and principles produced by basic research in the social sciences, is analogous to that in any other field of science. Invention has often come into being empirically, without benefit of, and in anticipation of, the development of fundamental theory. In the electric storage battery, for instance, the invention was empirical and the theory came later. So, also, with the wheel and the Code of Hammurabi. In many other cases, theory pointed the way to solution of a technological or social problem, such as Albert Einstein's theory of the equivalence of matter and energy that led to the discovery of nuclear energy, or the Pavlov and Skinner theories of conditioned response and reinforcement that led to the teaching machine. In other cases, refinement of understanding led to the correction of a misconception—such as the notion that metals failed by "crystallization," that alcohol

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[85] Karl W. Deutsch, John Platt, and Dieter Senghass, "Conditions Favoring Major Advances in Social Science," *Science* (Feb. 5, 1971, pp. 450–459. See also their expanded version of this study: "Major Advances in Social Sciences Since 1890: An Analysis of Conditions and Effects of Creativity," Communications 273 (Ann Arbor: Mental Health Research Institute, The University of Michigan, May 1970), 98 pages.

[86] James A. Hightower, "Some Social Science Studies and Projects Which Have Had an Effect on Public Policy," A draft study prepared according to the instructions of the Senate Subcommittee on Government Research, Government and General Research Division, Legislative Reference Service, Library of Congress (July 7, 1969), 8 pages.

potations were a specific for snakebite, that insanity resulted from exposure to moonlight, or that criminal tendencies could be eradicated by severe enough punishment.[87]

Software

Originally, dry goods—cloth and related materials. With the advent of the digital computer, the term has taken on a special meaning. The computer itself, its permanent and temporary memory banks, its consoles, readers, and linkages, are called "Hardware," (q.v.). To distinguish the programs telling the computer what to do, and the "language" to be used in communicating with the computer, these elements are referred to as "Software."

Specification

A description of an item, intended for referencing in purchase documents. The description may cite Standards (q.v.), or describe how and from what materials the item is to be made; or how it is required to perform.

Spin-Off

A shorthand term for a sequence in which technology developed expressly for major (mainly aerospace) governmental purposes is then applied elsewhere with economic benefit. It is identical with the "horizontal" form of Technology Transfer (q.v.).

The encouragement of Spin-Off often requires some additional development and almost always requires a repackaging of information to make the innovation available in the new context. This effort is referred to as "technological utilization" (i.e., Technology Utilization). Such organizational arrangements as the State Technical Services Act and local technology utilization centers have sought to encourage and facilitate Spin-Off.

Standard(s)

Units, quantities, procedures, agreed to by consensus or imposed by decree, and available for reference in the reporting of scientific discoveries, in specifications and other procurement documents, and in international or other technical communications of all kinds.

In endeavoring to explain its mission, the National Bureau of Standards begins: "If men are to accomplish together anything useful they must, above all, be able to understand one another." The Bureau then distinguishes between "the setting of fundamental standards and the practice of standardization as conducted in industry."

> The former [the Bureau continues] has to do with definitions, with specifying clearly and exactly what technical words mean, in a fundamental and scientific sense. The latter may be concerned with commercial definitions, but it is primarily involved with the task of agreeing on limiting ranges of sizes and forms which shall be manufactured in large numbers.[88]

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[87] "Technical Information for Congress," Report to the Subcommittee on Science, Research and Development of the Committee on Science and Astronautics, 92d Cong., 1st sess., Science Policy Research Division, Congressional Research Service, Library of Congress (Washington, D.C., U.S. Government Printing Office, 1971). Revised Apr. 15, 1971.

[88] Foreword. Measures for Progress, A History of the National Bureau of Standards, U.S. Department of Commerce. (Washington, D.C.: U.S. Government Printing Office, 1966.)

A definition of "Standards" for industrial purposes is:

> Standards are practicable, profit-provoking solutions to recurring problems. Established tentatively, they are couched in objective terms and are based on the consent of those affected. They facilitate and often promote general usage of the best thoughts and practices on the subject being standardized. Standardization is an evolutionary process whereby standards are established.

The source of this definition offers the further comment that:

> A standard is the immediate consequence of the standardization process. It most often assumes the form of the printed document. However, it may with equal validity be a physical object such as a gage. It may be a sound, on the order of the radio signal. . . . It may be spoken, engraved in copper, hacked out of stone, or put to music. If it was developed in accordance with the basic tenets of standardization . . . it is a standard.

These "basic tenets of standardization" are: the consensus principle, evolution, solutions to recurring problems, measurables rather than generalities, practicability, dynamism, objectivity, and profitability. Then the author goes on to classify industrial standards as follows: specification, nomenclature, dimensional standards, testing methods, ratings, standard practices, simplification, and safety.[89]

State of the Art

A general term of applied science, engineering, and systems engineering. It refers to the level of useful development in some category of technology; it carries the implication that if design should call for performance requirements or a level of sophistication that exceeds the present stage of development it will invite a significantly increased level of engineering risk. Generally speaking, applied research has the purpose of advancing the State of the Art in the subject to which it is addressed, to reduce the engineering risk that might otherwise be involved.

Steady State

Although it is axiomatic that all systems in the universe tend to run down, nevertheless this process can sometimes be arrested for limited periods of time. In the organization of systems, it is the function of Feedback (q.v.) to arrest this. Such a period of arrestment, although never absolute or infinitely extended, is termed a Steady State. It is an approximation, a general balance, with no evident radical (exponential) or persistent deviation.

If it is recognized that all systems and all components of systems are in a dynamic state, then they are all in a state of continuous change. Under such a concept, the term "Steady State," as applied to the total system, suggests that (in the words of one respondent) "the rates and types of changes are such that the overall macro pattern remains undisturbed against the background flux of micro-changes." (Compare Homeostasis, for a condition in which macro and micro are reversed from this condition.)

[89] Benjamin Melnitsky, Profiting from Industrial Standardization (New York: Conover-Mast Publications, Inc., 1953, pp. 1–14.

Stochastic Process

A concept of statistical probability. (In drawing blindfolded one bean from a container holding four black beans and eight white beans, the chances are two to one that the drawn bean will be white.) The Research Analysis Corporation defines the terms as follows:

> The statistical concept underlying the prediction of the condition of an element of a larger group when the probable average condition of the larger group is known. For example, assume that an armored division, under certain circumstances, has on the average a certain number of tanks deadlined for unscheduled maintenance. The probability that any given tank under the same circumstances will be deadlined for unscheduled maintenance on a specific day is described by a stochastic process.

Suboptimization

Excessive attention to the quality of one component of a larger system to the detriment of total system performance. Literally, it means optimization of a subordinate part; but since all systems represent compromise of component quality toward total system performances, with limited total resources available for the whole, the devoting of excessive resources to one part takes away essential resources from others. For example, a school system that overemphasized (suboptimized for) automobile repair would degrade general educational quality of its graduates.

Symbiosis (Also, Symbiotic Relationship)

Symbiosis is the living together of two species (plants and animals) for the benefit of one or both members. If one member cannot live without the other under natural conditions, the relationship is called "mutualism." The most common example of mutualism is the actual union of algae and fungi to form lichens, the crusty, gray-green plant found on rocks and trees. Another form of symbiosis is "commensalism," a rather lopsided arrangement in which one member benefits without harming the other. An example is birds feeding on the lice and ticks of grazing animals. Commensalism is very common in the ocean where sponges, shellfish, and burrowing worms support other forms of life almost without exception.

In a broader sense, the food chains in nature illustrate a kind of loose symbiosis: They illustrate how all parts of the world of nature are interwoven, with a never-ending process of dependency of one species upon another.

An analogous concept of symbiosis can be conceived of in industry, with various types of dependency of one industrial activity on another. For example, in the textile industry an associated industrial activity is that of the loom-fixing company. A more elaborate (though hypothetical) example might be an association between a cement plant and a paper mill, with dust from the former used as sizing by the latter and waste lignin from the latter used as an additive in the cement.

Synergistic Effects

When two causes produce similar effects, but when applied together produce an effect significantly greater in magnitude than the sum of effects from the two causes taken separately, the intensification is called "Synergistic" and the phenomenon "Synergism." A contemporary example would be the physiological/psychological effect of ingesting alcohol and a tranquilizer drug together.

Synoptic Measurements

Sometimes a measurement of one factor or element in an experiment (physical, biological, social) yields no significant meaning but the measurement—more or less in concert—of several elements or parameters can provide important insights. These are Synoptic Measurements; they contribute to interpretation of scientific events and influence research policy.

Synthesis

Almost the antonym of Analysis (q.v.). Used in its basic "combining" sense, e.g., the assembly of often varied and diverse ideas, forces, or factors into one coherent and consistent whole.

Synthetic Fuel (Synfuel)

Synthetic fuels are energy products obtained chemically from oil shale, tar sands, by coal gasification (synthane) or coal liquefaction (synthoil), or by a process (pyrolysis) in which organic materials are converted to a petroleum liquid by heat in the absence of oxygen.

System

This term involves the idea of complex, interrelated elements or components working effectively together in harmony to yield a single desired result. A Rand Corporation research memorandum defines "system" as "a set of interrelated factors that are used together to produce an output.[90]

Most systems also involve communications from a central control point, governing the operation of subsystems and reporting back to the control point, at which operating decisions are made (so that the system possesses the capability of self-adjustment or self-correction). See Feedback.

According to one student: "A system is a set of objects with relationships between the objects and between their attributes." He continues:

Objects are simply the parts or components of a system, and these parts are unlimited in variety. Systems may consist of atoms, stars, switches, springs, wires, bones, neurons, genes, gases, mathematical variables, equations, laws, and processes.

Attributes are properties of objects. For example, in the preceding cases the objects listed have (among others) the following attributes:

stars—temperature, distances from other stars
switches—speed of operation, state
springs—spring tension, displacement
wires—tensile strength, electrical resistance

[90] Joseph A. Kershaw and Roland N. McKean, "Systems Analysis and Education," Rand Research Memorandum RM-2473 (Oct. 30, 1959), p. 2.

Relationships tie the system together. In fact, the many kinds of relationships (causal, logical, random, etc.) make the notion of "system" useful.

For any given set of objects, it is impossible to say that no interrelationships exist since, for example, for a particular physical system, one could always consider as relationships the distances between pairs of the objects. The relationships to be considered in the context of a given set of objects depend on the problem at hand, important or interesting relationships being included, trivial or unessential relationships excluded. The decision as to which relationships are important and which trivial is up to the person dealing with the problem. . . .[91]

One simple and useful definition is: ". . . a goal-oriented enterprise." (The definition continues) :

It is characterized by formal procedures for defining goals, for identifying the tasks necessary to the achievement of these goals, for organizing to accomplish the tasks, for measuring one's success, and for revising the process as experience (data) dictates.[92]

See also Systems Analysis.

System(s) Analysis (Also, System(s) Approach)

The development of a system requires that a complete array of the relevant analytical methodologies (cf. Analysis) is brought to bear, each contributing its own individual methodology and serving its own particular purpose. The actions resulting from the products of these different analyses are harmonized to produce a coherent structure possessing Effectiveness (q.v.). The sum total of the process described is signified by the term System or Systems Analysis. According to one source—Systems Analysis is

> * * * inquiry to aid a decision-maker [in choosing] a course of action by systematically investigating his proper objectives, comparing quantitatively where possible the costs, effectiveness, and risks associated with the alternative policies or strategies for achieving them, and formulating additional alternatives if those examined are found wanting. Systems analysis represents an approach to, or way of looking at, complex problems of choice under uncertainty, such as those associated with national security. In such problems, objectives are usually multiple, and possibly conflicting, and analysis designed to assist the decision-maker must necessarily involve a large element of judgment.[93]

In characterizing the effectiveness of systems, main reliance is placed on quantitative data. Criteria of performance are expressed in numbers, as are cost, configuration, and maintenance data. Irrespective of the disciplines used in designing and developing a system, the facts extracted and used in the process of analysis will tend to be expressions of qualitative relationships.[94] See also Systems and Analysis.

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[91] A. D. Hall, *A Methodology for Systems Engineering* (New York, Van Nostrand, 1962), p. 60.

[92] However, this addition seems to confuse the idea of System with that of Systems Approach, and combines the two. Source: James A. Mecklenburger and John A. Wilson, "Learning C.O.D.," *Saturday Review* (Sept. 18, 1971), p. 64.

[93] E. S. Quade, ed., *Analysis for Military Decisions* (Chicago: Rand McNally, 1964), pp. 3–4.

[94] In comment on this point, one respondent suggested that the "realities of any given situation (under analysis) may push one to the point of having to deal quantitatively or parametrically with some portions of the analysis."

Emphasis in Systems Analysis is on the total performance of the whole system, as measured in parameters judged of primary importance, toward the system goal or mission. However, it is inherent in the System concept that there be coherence internally within the system as well as balanced compatibility with the external environment.

Systems analysis is a part of a total methodology, or way of thinking about things, called the systems approach. The systems approach encompasses the awareness and treatment of:

> Total system objectives and, more specifically, the performance measures (or standards, measures of effectiveness, or measures of merit) of the whole system;
>
> The system's environment, the fixed constraints;
>
> The resources of the system;
>
> The components (or subsystems, missions, or submissions) of the system, their activities, goals, and measures of performance; and
>
> The management of the system.[95]

Systems analysis is a term which has become associated generally with the concept of using "scientific" methods for the solution of broad problems lying outside as well as within the confines of the physical sciences. A number of other terms, however, have also become associated with this concept; among them are operations research (OR), systems engineering, planning-programming-budgeting system (PPBS), cost-effectiveness analysis, and management science. Increasing usage of these terms in many aspects of government and business activity reflects a current trend toward the infusion of scientific methodology in decision-making and policy-making processes in a large number of diverse areas. Often certain of these terms are used interchangeably, while on other occasions definite distinctions are made between them. The scope and characteristics of the activities carried on under these names vary widely, and there is not complete agreement among practitioners as to their proper definitions and range of applicability. Nevertheless, the acknowledged effectiveness and increasing use of systems analysis and related techniques calls for greater general comprehension of its meaning.

Technique

Wilkinson, in his translator's note to Ellul's *La Technique*, describes the scope of the title as the "organized ensemble of *all* individual techniques which have been used to secure any end whatsoever." Lasswell is quoted in this same source as defining [Technique] as "the ensemble of practices by which one uses available resources to achieve values." According to Merton's interpretation of Ellul, the French writer sees technique as "any complex of standardized means for attaining a predetermined result." [96] It seems impossible to distinguish Technique from Technology (q.v.).

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[95] C. West Churchman, *The Systems Approach* (New York: Dell Publishing Co., Inc., 1968), pp. 29–30 ff.

[96] Jacques Ellul, *The Technological Society*, translated from the French by John Wilkinson, with an introduction by Robert K. Merton, first American edition (New York: Knopf, 1964), p. vi.

Technological Fix (or, T. Quick Fix)

See Quick Fix.

The term "Technological Fix" was explored by Dr. Alvin M. Weinberg [97] as an innovation devised for the purpose of correcting a social defect. For example, a drug taken orally to prevent unwanted conception as a measure of population control. Emphasis of the concept is on first-order consequences of socially useful technology. The significance of the term is conditioned by the meaning attached to "technological." When the scope of the term is considered as sharply limited to mechanical contrivances, the "fix" becomes mechanical, although its social consequences can still be broad. As the scope of the term "Technology" extends to the biological and social sciences, and to management techniques and financial controls, the meaning of the term "Technological Fix" begins to overlap with that of technology assessment and science policy generally.

Technological Lag

Generally, a technological lag can be said to exist in a firm, industry, or national industrial system when a Technology Gap (q.v.) can be perceived between levels of technological potential or achievement. Evidences of an assertedly developing lag in U.S. technology vis-a-vis that of Western Europe and Japan are the decline in U.S. industrial productivity growth, both of labor and capital, and a deterioration in the U.S. foreign trade position.

Michael Boretsky, an economist with the U.S. Department of Commerce, has identified three causes of what he considers the recent loss of U.S. technological advantage: a lower growth in investment in new industrial plant and equipment in the United States than in other industrialized countries since the early 1950s; an underinvestment in economically relevant research and development relative to other industrialized countries since the beginning of the 1960s; and a worldwide and practically one-sided Diffusion (q.v.) of existing U.S. advanced technology in the form of patent rights and licenses together with appropriate instructions, blueprints, and other technical assistance since the end of World War II and particularly since the end of the 1950s.[98]

Technological Obsolescence (Also, Technology Obsolescence)

A reduction in absolute or relative Cost/Effectiveness (q.v.) of a technological system, product, component, or input, caused by a change in the external circumstances surrounding it. (Historically, technological obsolescence has been associated most closely with economic criteria, but the term "Effectiveness" (q.v.), used in the definition, reflects here a broader scope of criteria.)

Obsolescence usually implies the appearance of a superseding item or operation economically or functionally superior. Various other forms of obsolescence are also possible: for example, a finding that a

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[97] Alvin M. Weinberg, "Can Technology Replace Social Engineering?" *Bulletin of the Atomic Scientists* (December 1966).

[98] See Boretsky, Michael, "Trends in U.S. Technology: A Political Economist's View," *American Scientist*, Vol. 63 (January–February 1975), pp. 70–82.

given technological artifact, process, or system has social or medical dysfunction, like the drugs heroin or thalidomide, or a recognition that environmental consequences may be commandingly adverse, as with some of the organic synthetic pesticides.

It is noteworthy that Assessment of Technological Obsolescence has not attracted attention as an appropriate subject for policy study to the extent that Technology Assessment has done, yet the Side Effects of such obsolescence can be serious. Examples are the economic decline of Appalachia as a consequence of the technological obsolescence of coal as principal fuel, the loss of agricultural productivity that could result from restrictive regulation of pesticides, and the disruptive effect on industry of premature or arbitrary regulation against air and water pollution.

A respondent comments: I would include also the impact on manpower when made obsolete by the waning of skills and the overtaking by new technical growth. In the past, the impact of automation has been of concern in this regard; more recently, the need for conversion and retraining has been of public interest in connection with scientific and engineering unemployment.

Technology

Compare Technique.

The term "Technology" in its earliest usage signified mechanical tools and implied machinery of various kinds. However, it has come to signify tools and their development and use in the broadest possible sense. It encompasses any systematic employment by man of the cause-and-effect relationship (cf. Science) or empirical (cut-and-try) methods to achieve some desired purpose. It is the opinion of the author of the Glossary that the purpose of all technology can be generalized as an attempt to modify in some intended and desired way the relationship or compatibility of man and his environment.

Accordingly, technology encompasses all basic and applied research, all Edisonian inquiry, all manufacture and use of products, all knowledge rationally applied to agriculture, biomedicine, applications of sociology and other behavioral sciences, and any other rational human actions toward intended results.[99]

It is hard to distinguish the boundary lines between basic and applied science and technology. The point is that both basic and applied science are a part of technology. Thus, basic science is an information function; and applied science is an information function with a useful purpose in mind; while technology is the development and social use of information. A great deal of technological innovation, over the years, came into being without the aid of science; and conversely, a great deal of the information uncovered by science has not found useful application but is still judged as potentially useful, or as the basis for useful understanding.

A distinction can be drawn between technology as a process and as a product. One author suggests: "Technology-as-process is those pat-

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[99] For a discussion of this definition, see: Franklin P. Huddle, "Government Technology Assessment: The Role of the Social Sciences," Science Policy Research Division, Legislative Reference, Library of Congress, Multilith No. 10-246 SP (Oct. 2, 1970).

terns of action by which man transforms knowledge of his environment into an instrument of control over that environment for the purpose of meeting human needs. Technology-as-product is understood as comprising the range of tools, machines, procedures, etc., produced as results of technological action." [100]

A respondent observes that the word "Technology" has very strong emotional connotations for some people, who read into it notions about "the Establishment," "Free Enterprise," "Excessive Rationality," "Big Business," "the Military-Industrial Complex," and others. He observes: "You can't overlook, in your Glossary, these secondary meanings."

An interesting trend in the meaning of Technology is revealed by a comparison of the definitions in the Merriam-Webster 2nd and 3rd editions. In the 2nd edition, the word is defined:

> 1. Industrial science; the science or systematic knowledge of the industrial arts, esp. of the more important manufacturers, as spinning, weaving, metallurgy, etc.
> 2. Terminology used in arts, sciences, or the like.
> 3. Any practical art utilizing scientific knowledge, as horticulture or medicine; applied science contrasted with pure science.
> 4. *Anthropol.* Ethnotechnics.

Contrast this definition with that in the Merriam-Webster 3rd edition, which is as follows:

> 1. The terminology of a particular subject: technical language
> 2. a: the science of the application of knowledge to practical purposes: applied science (the great American achievement has been . . . less in science itself than in ---- and engineering—Max Lerner) b(1): the application of scientific knowledge to practical purposes in a particular field (studies are also made of polymeric materials to dental ----—Report: Nat'l Bureau of Standards) (2): a technical method of achieving a practical purpose (a ---- for extracting petroleum from sale) 3: the totality of the means employed by a people to provide itself with the objects of material culture.

Technology Assessment

A generalized process for the generation of reliable, comprehensive information about the chain of technical, social, economic, environmental, and political consequences of the substantial use of a technology, to enable its effective social management by decisionmakers.

Initially advanced as an instrument to provide advice to political decisionmakers, the concept has been increasingly accepted as a policy service within corporate management of private businesses.

As originally conceived, in a bill introduced by Congressman Emilio Q. Daddario, in 1967, the process was described as—

> * * * identifying the potentials of applied research and technology and promoting ways and means to accomplish their transfer into practical use, and identifying the undesirable

[100] S. R. Carpenter, "The Structure of Technological Action. Ph. D. dissertation, Boston University, 1971, p. 28. Italics in original not followed.

by-products and side-effects of such applied research and technology in advance of their crystallization and informing the public of their potential in order that appropriate steps may be taken to eliminate or minimize them.

In the study, *Technical Information for Congress*, Technology Assessment was defined in the following passage:

> Before, during, and after the building of a technological system, it is necessary to identify and study the consequences of its operation. The objective is to improve the management of the total technological society, including the minimizing of consequences which are unintended, unanticipated, and unwanted. Assessment includes forecasting and prediction, retroactive evaluation, and current monitoring and analysis. Measurements involve non-economic, subjective values as well as direct, tangible quantifications. Above all, assessment requires that catastrophic consequences of each proposed new technology be foreseen and avoided before the new technology becomes entrenched in the socioeconomic complex of human organization. Above all, irreversibly, adverse consequences need to be foreseen and avoided.[101]

A study of Technology Assessment by the National Academy of Sciences [102] accepted the Daddario definition (above) but devoted many pages to an intensive examination of its implications, in terms both of the process required and the institutional mechanisms for its implementation.

A study of the subject by the National Academy of Engineering [103] distinguished two different kinds of Technology Assessment: problem-initiated and technology-initiated assessments. These were:

1. Assessments directed to the solution of identified problems of society which are usually amenable to systems analysis for their solution; and
2. Assessment to enable society to cope with the unfolding chain of cause-and-effect relationships stemming from a new technology.

It has been suggested that to these should be added two other kinds of Technology Assessment. These are:

1. Policy-oriented studies; and
2. Studies undertaken (usually in an academic environment) for the purpose of developing an assessment methodology, rather than as an input to decision-making.[104]

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[101] "Technical Information for Congress," op. cit., p. 481.

[102] "Technology: Processes of Assessment and Choice." Report of the National Academy of Sciences to the Committee on Science and Astronautics. U.S. Congress. House, 89th Cong., 2d sess. (Washington, D.C.: U.S. Government Printing Office, 1969).

[103] "A Study of Technology Assessment." Report of the Committee on Public Engineering Policy, National Academy of Engineering to Committee on Science and Astronautics, U.S. Congress. House, 89th Cong., 2d sess. (Washington, D.C.: U.S. Government Printing Office, 1969), pp. 14–16.

[104] For a more detailed description, see "The Future of Technology Assessment in Policy Formulation" by Walter A. Hahn, in *Technology Assessment in a Dynamic Environment*, M. J. Cetron, B. Bartocha, and C. Ralph (eds.), New York, Gordon and Breach (currently in press). Hahn offers the further explanation as follows: "Policy-oriented TA is of major interest to the legislative and, to some extent, executive branches of the several levels of government. Assessments to determine the impact of old, new, or proposed technological structures, products, or processes are more usually associated with industrial or government regulatory agencies. Problem- or issue-oriented TAs arise from the feeling that 'something is going wrong,' often articulated by industrial citizens, groups, or public-interest organizations. This has been referred to as 'people's technology assessment.' * * * Persons in academic and not-for-profit organizations emphasize the conceptual and methodological aspects of TA and push for the development of the techniques, quality assurance, and objectivity so necessary for the viability of TA."

The author of this glossary is not persuaded of the validity of these last two additions, however, because the first ought to be the product of all assessments, and the second yields no substantive assessment at all.

In the Report of the President's National Goals staff, a chapter was devoted to the subject of Technology Assessment. In it was presented a further definition, as follows:

> A systematic planning or forecasting process that delineates options and costs, encompassing economic, environmental, and social considerations (both external and internal) and with special focus on technology-related "bad," as well as "good," effects.[105]

Out of these definitions emerges a concept of a purposeful and iterative search for significant secondary consequences and side effects (the "total impact") of a technology; identifying affected parties; evaluating the social, environmental, and cultural impacts; considering feasible technological alternatives; and revealing constructive opportunities; with the intent of managing technology more effectively to achieve societal goals. The process is a neutral and objective structuring of information about tradeoffs, priorities, options, and alternatives, to promote effectiveness in management decisions in the control and use of technology—not only in the present but for an indeterminate future.

It is essential that the process not be confused with the decision process, but rather that it be recognized as an input to it. This point was elaborated in *Technical Information for Congress* in the passage—

> In the management of a political issue with substantial scientific or technological content, the political issue is always larger in scope than the scientific question within it. In principle, the scientific question needs to be dealt with first. It is important that the scientific question or issue be carefully framed so that the answer to it provides a useful and significant piece of evidence for guidance in the consideration of the broader political issue.[106]

Moreover—

> * * * Every technical decision that provides the underpinning for a major political decision should receive adequate professional consideration, and * * * the outcome and its justification need to be expressed in terms meaningful to those responsible for the political decision.[107]

Accordingly, it is suggested that the process of Technology Assessment is one of three elements in the management of technology by society. The first is the process of science and technology, producing innovations as solutions to social problems and needs. These may be economically attractive, or may require public funding; either way, they may become candidate claimants for political decisionmaking. The second element is the assessment of these technologies as solutions.

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[105] National Goals Research Staff, "Toward Balanced Growth," op. cit.
[106] See p. 506.
[107] See p. 516.

The third element is the political process by which the social benefits and costs are finally judged and appropriate public action decided upon. Technology Assessment, then, is the technological information input to the political decision process.[108]

Technology Forecasting

(Also called "Technological Forecasting," although this usage is suspect.) In general, Technology Forecasting signifies the estimating of probable availability or use of a technological innovation at some specified future time. According to Jantsch: [109]

> *Technological forecasting* is the probablistic assessment, on a relatively high confidence level, of future technology transfer. *Exploratory technological forecasting* starts from today's assured basis of knowledge and is oriented towards the future, while *normative technological forecasting* first assesses future goals, needs, desires, missions, etc. and works backward to the present. (Gabor.) The subject of both types is a dynamic picture of a technology transfer process. Technological forecasting may be aided by anticipation and may "harden" to prediction.

Technology Gap

This is a shorthand expression referring to a perceived inequality in national level of technological potential or achievement, as evidenced by national differences in such characteristics as percentage of gross national product allocated to scientific research, rate of investment in new capital formation, numbers of new products appearing on the national market, educational level attained by the population, character of exports and imports as "high" or "low" technology, etc. Various publications have offered strategies for closing the "gap" and others have addressed the question as to whether or not such a gap in fact existed or could be precisely characterized or measured. *The American Challenge*, by J. J. Servan-Schreiber, erects an elaborate thesis around the proposition that there is a gap, favoring the United States, and that it can be closed by positive and concerted action of European countries. The studies by Michael Boretsky, an economist with the U.S. Department of Commerce, advance the thesis that there has been a gap—favoring the United States—and that it is attributable to past U.S. efforts supportive of research and development leading to the simulating of innovations in "high technology" (q.v.), but that such an asserted superiority is short-lived and waning.

Technology, High

A loosely defined and imprecise term that appears to carry the implication that some kinds of technological innovation involve a higher content of scientific input than others. While it is true that some tech-

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[108] One respondent questions this concept of technology assessment as a "pure" technical process aloof from the political decisionmaking process. He questions not only its feasibility but even its desirability.

[109] Erch Jantsch, *Technological Forecasting in Perspective* (Paris, Organization for Economic Cooperation and Development, 1967), p. 15.

nologies have been developed empirically, nevertheless it should also be recognized that all technological innovations are amenable to improvement by the systematic application of Science (q.v.). Perhaps the nearest approach to precision of a definition of High Technology would be: hardware developments relying extensively or chiefly on recent discoveries of the Physical Sciences (q.v.) for their operational principle. Perhaps an equivalent term might be "Technology Intensive."

Examples of developments usually cited as belonging in the category of High Technology are aerospace, electronic, computer, and nuclear systems. Low Technology, by contrast, would encompass such industries as textiles, glass-blowing, iron casting, and wood manufacturing. However, in even the most traditional classes of industries it is possible to find evidences of intensive application of technology. In textile weaving, for example, the multi-dimensional weaving of unconventional fibers is a recent development. In fact, even in agriculture a very large scientific and technological component is evident.

Technology Intensive

See Technology, High.

Technology, Intermediate

Intermediate Technology is a term introduced and popularized by E. F. Schumacher to represent a level of technology partway between the primitive, indigenous technology of underdeveloped countries and the highly sophisticated technology of industrially-developed countries. As viewed by Schumacher, Intermediate Technology would help provide what the poor people of developing countries most require, for example, building materials, clothing, household goods, agricultural implements, water and crop storage facilities, and the means for processing the first stages of their agricultural products.

"Intermediate technology does not imply simply a 'going back' in history to methods now outdated. * * * The development of an intermediate technology * * * means a genuine forward movement into new territory, where the enormous cost and complication of production methods for the sake of labour saving and job elimination is avoided and technology is made appropriate for labour-surplus societies." [110]

Technology, Public

An aspect of Technology Transfer (q.v.) mainly concerned with the transfer of technology for solving some of the major problems of society, particularly urban living, including solid waste management; municipal services, like police, fire, and health; traffic systems; housing and construction; municipal management and information systems; and pollution control.

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[110] Schumacher, E. F., *Small Is Beautiful: Economics as if People Mattered* (New York: Harper and Row, 1973), p. 187. See also Schumacher, E. F., "Intermediate Technology," *The Center Magazine*, vol. 8, No. 1 (January/February 1975), pp. 43–49.

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Technology Transfer

This complex and incompletely understood process involves Communication (q.v.) in which the message contains technological elements. The transfer can be vertical (i.e., successive transmissions of ideas cumulatively toward a complete design or process) or horizontal (from one user to another). Either kind of transfer can be intranational or international.

An excellent example of the various stages of this process is presented by the development and deployment of the Pilkington float glass process. This Innovation (q.v.) was developed in England, based on an American patent (Invention, q.v.). The process was perfected and put to work first in England and then licensed to other producers in a number of foreign countries. It is not unlikely that some of these licensees will in due course introduce further improvements on the process, and that these in turn will be transferred back to the originating company.

Technology Utilization

Technology Utilization is a process or mechanism whereby knowledge is put into action. It may be viewed as a means by which existing research knowledge is adapted and applied operationally to useful processes, products, or programs which meet actual or potential public or private needs. The term implies the transfer of existing or new knowledge from its developers to users of research such as policy makers and managers. According to Gruber and Marquis,[111] Technology Utilization emphasizes the ability or willingness of an entrepreneur (public or private) to apply available technology to an ultimate use or creation of a marketable end product. It is roughly synonymous with Innovation (q.v.) in its emphasis on commercial application.

Theory

A principle or body of principles propounded to explain phenomena, generally based upon scientific reasoning and often supported by Empirical (q.v.) evidence. Theory, based mainly on a *priori* reasoning processes, may be contrasted with Empiricism (q.v.), which is based mainly on *a posteriori* observation and experimentation, although both theory and empiricism make use of both types of processes.

When a theory has been adequately tested and substantiated by scientific methods, and is generally considered "proven" by the scientific community, it may be termed a law, like Newton's laws of motion or the laws of thermodynamics. However, if a theory is still subject to some doubt or has not been substantiated, it would remain a theory in the parlance of science and technology. In this sense, there is a fine distinction between a law and a theory.

Often theory is treated loosely as being synonymous with hypothesis. More accurately, however, a theory is a more or less verified or established statement of known phenomena while a hypothesis tends toward conjecture. A continuum of less- to better-established principles might

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[111] See, for example, Gruber, William H. and Donald G. Marquis, editors, *Factors in the Transfer of Technology* (Cambridge, Massachusetts: The M.I.T. Press, 1969), 289 p.

range from hypothesis through theory to law, with some overlapping of meanings from one word to another.

See Science.

Threshold

The lowest level or concentration at which a particular phenomenon affects a system; also commonly, but erroneously, the lowest level or concentration at which a particular phenomenon can be detected. For example, the levels at which a human hears sound or feels pain are the threshold levels of sound and pain, respectively; the threshold of a change in a physical substance may be measured, for example, in terms of the boiling or freezing temperatures of the substance or by related changes in the Ambience (q.v.).

The determination of threshold levels may often be constrained by the limitations of detection devices. For example, some substances or radiation in any amounts may cause Toxicity (q.v.), particularly chronic poisoning. The apparent threshold of toxicity in such cases would be the level of detection registered by detection devices, rather than the actual, and perhaps much lower, threshold of toxicity caused by the first absorption of toxic substances or radiation by living tissues.

The concept of threshold presents problems in the regulation of some kinds of environmental insults. The threshold for acute toxicity is higher than the threshold for chronic toxicity. In the case of radiation, there are two conflicting concepts of threshold: one is that all radiation exposure, no matter how small, is injurious to exposed human tissue so that there is *no* threshold; and the other is that a threshold exists which is determined by the rate at which the human organism is able to repair radiation damage.

Toxicity (noun)

Toxicity, or poisonousness, has become an increasingly important subject as the environment has become more polluted. Toxins in the atmosphere, soil, and water in the form of fertilizers, pesticides, and herbicides, and industrial, vehicular, human, and animal wastes, as well as radiation, may poison humans directly or may be introduced into foods and transferred to humans through links in the Food Chain (q.v.) Poisoning may be acute or chronic depending upon the toxicity of the agent, the rate of intake of the poison, and the rate of onset and the duration of the symptoms.

> Acute poisoning, typically, is characterized by rapid absorption of the offending material and the exposure is sudden and severe. For example, inhaling high levels of carbon monoxide or swallowing a large quantity of cyanide compound will produce acute poisoning. The death or survival of a victim through the critical period occurs suddenly. Generally, acute poisoning results from a single dose which is rapidly absorbed and damages one or more of the vital physiological processes. The development of cancer long after recovery from acute radiation damage is called a delayed acute effect.

Frequently repeated and extended exposures over a period of several hours or days, results in subacute effects, depending on the dose rate.

Chronic poisoning is concerned with the continued absorption over a long period of time of a harmful material in small doses; each dose, if taken alone, would barely be effective. Chronic poisoning is characterized by the harmful materials remaining in the tissues, continually injuring some body process. The rate of intake exceeds the rate of excretion or detoxification; thus chronic poisoning can lso be produced by exposure to a harmful material which produces irreversible damage, so the injury accumulates, rather than the poison. The symptoms in chronic poisoning are usually different than those seen in acute poisoning by the same toxic agent.[112]

Not all individuals react in the same manner to the same amount of a harmful material. Such an atypical response to chemicals presents problems to those concerned with setting occupational and public health standards. To screen out hypersensitive individuals from exposed occupations or environments may involve the use of predictive tests.

The toxicity of substances is often expressed in terms of the Lethal Dose which is required to cause death in 50 percent of an exposed population (LD–50), usually within 30 days. An LD–50 level for humans is typically determined by subjecting a test population, like rats, to toxic substances and extrapolating the results to humans based upon the amount of lethal toxins given to, and the body weights of, the test population.

Trade-Off (noun, verb)

Foregoing some portion of one benefit in order to achieve some increased portion of another benefit; (or) foregoing some portion of a benefit in order to achieve a reduction in some portion of a cost; (or) accepting an increased portion of one cost in order to achieve a decrease in the portion of another cost. Other more complicated permutations of this concept can be suggested. The term is in wide usage.

Tragedy of the Commons

The principle that the maximization of private gain will, in some cases, not be regulated by a device like the "invisible hand" of Adam Smith, which typically serves as a national self-regulator of economic activity.

The "Tragedy of the Commons" alludes to a situation in which each of several herdsmen seeks to maximize his gain by adding cattle to a common pasture. A herdsman could rationalize and justify his action in adding one animal to the commons on the basis that he would receive all the benefit of the additional animal while the detrimental effects of overgrazing caused by his action would be shared equally by all the herdsmen. In this type of situation, some form of governmental regulation might be required to prevent the economic ruin of those who share the commons. The principle of the Tragedy of the Commons

[112] Julian B. Olishfski and Frank E. McElroy, *Fundamentals of Industrial Hygiene* (Chicago : National Safety Council, 1971), pp. 417–18.

is found in many societal problems, like environmental pollution and overpopulation, particularly those involving any "free" or common good or service, like air, water, procreation, and sometimes land.

This principle was first propounded by William Forster Lloyd in 1833. Professor Garrett Hardin of the University of California at Santa Barbara has recently expanded upon Lloyd's work and given the principle its name.[113]

Transnational Corporation

See Multinational Corporation.

Trend Extrapolation

A form of forecasting in which the assumption is made that the rate of time-dependent change of a phenomenon will continue in the future at the same level as in the past. For example, electric power generating capacity in the United States has approximately doubled every decade since 1920. Trend extrapolation would predict that it will continue to double over each future decade. Such a simplistic approach, of course, ignores the fact that the rate of increase of electric power in its infancy was not this fact, and that future change may level off or even decrease. (Comments a respondent: [Trend Extrapolation] has the same problem as Delphi in the case of complex nonlinear feedback systems and can give highly misleading results for the same reason.) Graphically, the rate of change that begins slowly and increases to a sustained maximum rate before leveling out (becoming asymptotic to a horizontal line) is represented by an "S-Curve"; trend extrapolation, which cannot predict at what time (and for what reasons) the second knee in the S-Curve will be reached, simply ignores this subtlety by assuming that no knee exists. Similar difficulties are encountered in attempts to apply trend extrapolation to other phenomena exhibiting other forms of behavior.

Tribology

The word "Tribology" was coined by a British committee in 1966 from the word "tribos," which means "rubbing" in classic Greek. It may be defined as the science and technology of the interaction of material surfaces in relative motion. It is concerned with every aspect of operating hardware and equipment in which the relative motion of surfaces is involved and thus covers a wide range of phenomena. Tribology encompasses, essentially as an integrated system, the many facets of friction, lubrication, wear, bearing phenomena, hydrodynamics, fluid mechanics, surface sciences, and many classical disciplines like chemistry and physics. Tribology constitutes an interdisciplinary approach to these fields and to related design and engineering problems.

The U.S. practice emphasizes the use of the roughly comparable term "wear." An issue of the *ASTM Standardization News*, published

[113] Garrett Hardin, "The Tragedy of the Commons," *Science*, vol. 162, Dec. 13, 1968, pp. 1243–1248.

by the American Society for Testing and Materials (September 1974) contains an extended discussion of this class of phenomena.[114]

Value(s)

Desired functions. They may be expressed in many ways. Economic values are expressed in monetary terms. Parts of systems are evaluated in relevant parametric numbers. Social values can sometimes be quantified. (Cf. Social Indicators and Externalities.) Normative (q.v.) values are general social, ethical, cultural, or esthetic "goods" not subject to quantification.

Wisdom

Knowledge of how to use knowledge, including Science (q.v.).

[114] See especially Peterson, Marshall B., Maj-Britt K. Gabel, and Martin J. Devine, "Understanding Wear," and Ludema, Kenneth C., "A Perspective on Wear Models," in *ASTM Standardization News* (September 1974), pp. 9–12 and 13–17.

APPENDIX A

Chronology of Federal Executive Branch Science Organization: 1787–1975

Chronology of Federal Executive Branch Science Organization: 1787–1975 [1]

The following chronology, predominantly legislative action, traces the evolution of Federal concern in organizing to deal with problems relating to scientific and technical matters. While some of these actions may be looked upon as having a specialized application, the preponderance of them addressed problems of truly national scope, many as pressing as the problems the Nation faces today on the threshold of its third century.

1787: The Constitutional Convention considered scientific and technical matters to be included in the Constitution. Among the ideas discussed were the establishment of national seminaries and universities for the promotion of literature, the arts, and the sciences; charters of incorporation for national societies and institutions dedicated to the advancement of knowledge; and the establishment of public institutions, rewards, and subsidies to promote agriculture, commerce, and the advancement of useful knowledge and discovery.

1787: Science in the Constitution. The only specific reference to "science" in the Constitution is in Article I, Section 8: "The Congress shall have Power * * * To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries".

April 10, 1790: First patent act passed at request of President Washington. Secretaries of State, War and the Attorney General constituted a board to pass on inventions. Keeping records made responsibility of Secretary of State. (Act of April 10, 1790; 1 Stat. 109)

April 2, 1792: The United States Mint was established by Congress. (Act of April 2, 1792; 1 Stat. 246)

February 18, 1793: New patent act put Secretary of State in charge of patents. (1 Stat. 318)

July 16, 1798: Provision of medical care for merchant seamen by the Federal Government was authorized by Congress. Treasury Department was given administrative responsibility. The first marine hospital constructed with Federal funds was completed in 1800.

The U.S. Public Health Service traces its beginning to these hospitals. (1 Stat. 605)

April 24, 1800: Library of Congress was established by law approved April 24, 1800. (2 Stat. 56)

February 10, 1807: Coast Survey established under administrative direction of the Secretary of the Treasury by Act of Congress. (Act of February 10, 1807; 2 Stat. 413)

February 19, 1818: Surgeon General's Office and the Army Medical Department established with authority to prevent and treat disease and to collect weather data for processing and analysis. (3 Stat. 408)

1830: Secretary of the Navy established a Depot of Charts and Instruments, which later evolved into the Naval Observatory.

June 14, 1836: Secretary of the Treasury was directed to cause a complete set of all the weights and measures adopted as standards to be delivered to the Governor of each State for the use of the States. (Resolution No. 7; 5 Stat. 133)

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[1] This chronology appeared initially in U.S. Congress, House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development. *Centralization of Federal Science Activities*, 91st Congress, 1st Session (Washington, D.C.: U.S. Government Printing Office, 1969), pp. 37–50. [Committee Print.] The chronology, updated to include both key legislative and executive branch actions in the past decade, then appeared in U.S. Congress, House, Committee on Science and Technology, *A Proposed National Science Policy and Organization Act of 1975*, 94th Congress, 1st Session (Washington, D.C.: U.S. Government Printing Office, 1975), pp. 33–35. [Committee Print.]

July 4, 1836: Permanent office of commissioner of patents created. (Act of July 4, 1836; 5 Stat. 117)

August 31, 1842: By act of Congress a sum of $25,000 was authorized for a building for the Navy Depot of Charts and Instruments, later the Naval Observatory.

August 10, 1846: The Smithsonian Institution was chartered by Congress. Initial endowment came from gift of $500,000 from James Smithson in 1829. (9 Stat. 103)

March 3, 1849: Department of the Interior was established, taking over the General Land Office from the Treasury Department, the Office of Indian Affairs from the War Department, and the Pension Office and the Patent Office, which had been independent offices. (9 Stat. 395)

May 15, 1862: U.S. Department of Agriculture established. Among its missions was the systematic application of scientific methods to agriculture. The department was elevated to Cabinet status in 1889. (12 Stat. 387, ch. 72)

July 2, 1862: Morrill Act or Land Grant College Act passed providing for establishment in each state of at least one college to provide instruction in agriculture and the mechanic arts. The significance of the act was that it formally recognized the national need for trained manpower in selected fields, and established mechanisms for cooperative Federal and state government participation in financing academic activities related to science and research interests. (12 Stat. 503)

March 3, 1863: National Academy of Sciences was established by Congressional charter. (12 Stat. 806)

March 2, 1867: Office of Education was established. (14 Stat. 434)

1869: Office of Education became a part of the Department of the Interior.

July 8, 1870: Further general revision of the patent laws. (16 Stat. 198)

December 18, 1884: Joint resolution extending the time fixed for the joint commission (Allison Commission) appointed under the sundry civil act approved July 7, 1884, to consider present organizations of Signal Service, Geological Survey, Coast and Geodetic Survey, and Hydrographic Office of the Navy Department to secure greater efficiency and economy, to submit their report. (Joint resolution No. 1, 23 Stat. 515)

June 20, 1878: Coast Survey redesignated Coast and Geodetic Survey (20 Stat. 206, 215)

March 2, 1887: Hatch Act of 1887 further encouraged scientific agriculture by providing for agricultural experiment stations in the land-grant colleges. (24 Stat. 440)

October 1, 1890: Weather Bureau established within the Department of Agriculture. (26 Stat. 653)

March 2, 1901: Appropriations for the Department of Agriculture for fiscal year 1902 made separate appropriations for the Bureau of Chemistry, Bureau of Plant Industry, and Bureau of Soils, thereby establishing them as separate and independent bureaus. (31 Stat. 922)

March 3, 1901: National Bureau of Standards established in Department of the Treasury, replacing the Office of Construction of Standard Weights and Measures. The new bureau was given full powers over custody, preparation, and testing of standards and responsibilities for "the solution of problems which arise in connection with standards * * *." In addition to service to Federal, state and municipal governments, the bureau was to provide for a fee standards for nongovernmental units or individuals.

The legislation was an indication of the renewed willingness and ability of Congress to provide an administrative means of dealing with government science needs. [On February 14, 1903 the bureau became part of the new Department of Commerce and Labor, Public Law 87; 32 Stat. 825] (31 Stat. 1449)

March 6, 1902: Bureau of the Census was established in the Department of the Interior, giving permanency to an organization for the census in preference to the previous temporary organization set up every ten years and subsequently allowed to lapse. (Public Law 27; 32 Stat. 51)

July 1, 1902: A bill to increase the efficiency and change the name of the Marine Hospital Service to Public Health and Marine Hospital Service was enacted. The law authorized the establishment of specified administrative divisions, and, for the first time, designated a bureau of the Federal Government as an agency in which public health matters could be coordinated. (32 Stat. L. 712)

January 12, 1903: Secretary of the Interior was directed to transfer all census records and volumes to the Census Office. (Public Law 20; 32 Stat. 767) [Census office was transferred to Department of Commerce and Labor by act of February 14, 1903.]

February 14, 1903: Department of Commerce and Labor created by act of Congress. Section 12 authorized the President to transfer to the new department at any time all or part of any unit engaged in "statistical or scientific work" from the Departments of State, Treasury, War, Justice, Post Office, Navy, and Interior. (Public Law 87; 32 Stat. 825)

1903: A Committee on Organization of Scientific Work was appointed by President Theodore Roosevelt to consider the central organization of government scientific bureaus with primary emphasis on eliminating duplication. During the four months of its existence the Committee prepared a series of reports on individual government bureaus.

April 28, 1904: An act to incorporate the Carnegie Institution of Washington. The objects of the corporation "shall be to encourage * * * investigation, research, and discovery, and the application of knowledge to the improvement of mankind." (Public Law 260; 33 Stat. 575)

February 1, 1905: Transfer of forest reserves from Department of the Interior to Department of Agriculture; change of name of Division of Forestry to Forest Service. (Public Law 34; 33 Stat. 628)

March 16, 1906: The Adams Act of 1906 strengthened both financial support for agricultural experiment stations and their control by the Federal government, increasing annual funding but also restricting use of funds to "conducting original researches or experiments bearing directly on the agricultural industry of the United States." (Public Law 47; 34 Stat. 63)

April 23, 1908: A reorganization of the Medical Department of the U.S. Army providing for a Medical Corps and Medical Reserve Corps as well as the existing Hospital corps, nurse corps and dental surgeons. (Public Law 101; 35 Stat. 66)

May 16, 1910: Bureau of Mines established in the Department of the Interior. The principal duties of the bureau related to ways to improve conditions and safety in mines.

Functions authorized to be transferred from the U.S. Geological Survey related to investigations of structural materials, analyses of fuel substances (coal, lignites and other mineral fuels), and investigation of causes of mine explosions. (Public Law 179; 36 Stat. 369)

August 14, 1912: Under an act, the name Public Health and Marine Hospital Service was changed to Public Health Service. The legislation also authorized the Public Health Service to conduct field investigations and studies and, in particular, investigations of the diseases of man and pollution of navigable streams. The significance of this legislation was that by opening the whole field of public health to research by the government, it was recognized as a legitimate area of Federal activity. (Public Law 265; 37 Stat. 309)

February 25, 1913: By a new organic act the field of the Bureau of Mines was expanded by definition to include "mining, metallurgy, and mineral technology," thus extending the activities beyond the coal industry and for prevention of waste as well as mine safety. (Public Law 386; 37 Stat. 681)

March 4, 1913: Department of Commerce and Labor separated by act of Congress which created a new Department of Labor. (Public Law 426; 37 Stat. 736)

May 8, 1914: The Smith-Lever Act provided for cooperative agricultural extension work between the agricultural colleges receiving benefits under the Act of July 2, 1862 (the Morrill Act). Cooperative agricultural extension work (home and field demonstration) was also authorized for people not in the colleges. By this act the Extension Service of the Department of Agriculture was put on a separate and permanent basis. (Public Law 95; 38 Stat. 372)

March 3, 1915: The Advisory Committee for Aeronautics (later the National Advisory Committee for Aeronautics, or NACA) was established by a rider to the Naval Appropriations Act, "* * * to supervise and direct the scientific study of the problems of flight, with a view of their practical solution." The sum of $5,000 a year was appropriated for 5 years. The total appropriation for naval aeronautics was $1 million. NACA was the first war research agency of the World War I period. (Public Law 271; 38 Stat. 928)

July 1915. A Naval Consulting Board with Thomas A. Edison, chairman, was appointed by Navy Secretary Josephus Daniels. The Board whose membership was selected from the eleven largest engineering societies in the U.S. was intended to serve as a review and evaluation board for ideas and suggestions which might be developed for defense purposes.

1916: A National Research Council of the National Academy of Sciences was established to permit a larger part of the scientific community to assist in research in connection with national preparedness. Approval of the Council by a letter of July 25, 1916 from President Woodrow Wilson to the President of the NAS was formalized by the issuance of Executive Order 2859 of May 11, 1918.

August 25, 1916: National Park Service was established in the Department of Interior. National parks, monuments and reservations were placed under the supervision of the director who was responsible to the Secretary. (Public Law 235; 39 Stat. 535)

February 23, 1917: Smith-Hughes Act created a Federal Board of Vocational Education for promotion of vocational education in cooperation with the states. Appropriated funds for the training and salaries of teachers of trade, home economics, and industrial subjects. (Public Law 347; 39 Stat. 929)

October 1, 1917: Congress created the Aircraft Board to expand and coordinate the industrial activities relating to aircraft and to facilitate generally the development of air service. (Public Law 48; 40 Stat. 296)

October 27, 1918: A joint resolution establishing a Reserve Corps for the Public Health Service was passed. The 1918 influenza epidemic emphasized the need for a reserve corps in the Service to meet such emergency situations. (Public Resolution 45; 40 Stat. 1017)

June 10, 1920: Federal Power Commission was created to provide for the improvement of navigation, the development of water power, and use of public lands in relation thereto. The Commission was authorized to make investigations and collect data on the utilization of water resources, and on the water power industry. (Public Law 280; 41 Stat. 1063). (Amended to prohibit power projects in national parks or monuments unless specifically authorized by Congress: Public Law 369, March 3, 1921; 41 Stat. 1353)

June 10, 1921: Budget and Accounting Act, 1921. Established the Bureau of the Budget, provided for the annual submission of a consolidated Federal budget, and established a General Accounting Office. Henceforth, all Federal agency fund requests including research would have to receive central approval prior to transmission to Congress. (Public Law 13; 42 Stat. 20)

May 11, 1922: The appropriations act of the Department of Agriculture for fiscal year 1923 authorized the creation of the Bureau of Agricultural Economics out of miscellaneous already existing statistical and analytical activities. This has been cited as an example of the type of new social-science agencies which were created during the 1920's. (Public Law 217; 42 Stat. 531)

February 26, 1923: Bureau of Home Economics established in the Department of Agriculture by appropriations act for the department for fiscal year 1924. (Public Law 446; 42 Stat. 1315)

1923: Naval Research Laboratory was established. Its legislative basis goes back to initial sums appropriated in 1916 for a laboratory for the Naval Consulting Board.

February 24, 1925: The Purnell Act authorized additional funds to be appropriated for each agricultural experiment station for fiscal years 1926 and thereafter according to a graduated scale. Funds were to be used for necessary expenses of investigations relating to agricultural products including scientific researches on the "establishment and maintenance of a permanent and efficient agricultural industry." (Public Law 458; 43 Stat. 970)

April 13, 1926: An act amending the Morrill Act of 1862 to provide for investment of proceeds from public land sales, the establishment of a perpetual fund, and use of interest from the fund to be applied toward endowment or maintenance of colleges specializing in agriculture and mechanics, "without excluding other scientific and classical studies." (Public Law 113; 44 Stat. 247)

May 20, 1926: Air Commerce Act, 1926. This was the first Federal legislation regulating civil aeronautics. Gave the Department of Commerce wide powers over aviation. Research and development to improve air navigation facilities was specifically mentioned among the ways in which Congress directed the Secretary of Commerce to foster air commerce. He was also directed to make

recommendations to the Secretary of Agriculture concerning necessary meteorological service. (Public Law 254; 44 Stat. 568)

February 23, 1927: Radio Act of 1927. Created a Federal Radio Commission to be responsible for the regulation and control of radio transmission within the United States and of channels of interstate and foreign radio transmission. (Public Law 632; 44 Stat. 1162)

March 2, 1927: Amendments to the patent laws. Provided that examiners in chief shall have competent legal or scientific ability. Amended the appeals procedure. (Public Law 690; 44 Stat. 1335)

March 10, 1928: Authorized $900,000 to complete transfer of experimental and testing plant of Air Corps to a permanent site at Wright Field, Dayton, Ohio and for construction and installation of technical buildings. (Public Law 150; 45 Stat. 299)

April 30, 1928: Amendment to patent laws permitting issuing of patents to Government employees without fee when the invention is certified to be in the public interest: Inventions so patented must be made available for Government manufacture or use without payment of royalty. (Public Law 325; 45 Stat. 467)

May 22, 1928: Further amendment to Morrill Act of 1862 to authorize additional appropriations for cooperative extension work in agriculture and home economics. (Public Law 475; 45 Stat. 711)

January 19, 1929: The Narcotics Control Act provided for construction of two hospitals for the care and treatment of drug addicts, and authorized creation of a Narcotics Division in the Office of the Surgeon General of the Public Health Service. (Public Law 70–672; 45 Stat. L. 1085)

February 23, 1929: Benefits of the Hatch Act and the Smith-Lever Act relating to cooperative extension work between agricultural colleges were extended to the Territory of Alaska. (Public Law 797; 45 Stat. 1256)

March 2, 1929: Membership of the National Advisory Committee for Aeronautics increased from 12 to 15 members by act of Congress. (Public Law 908; 45 Stat. 1451)

April 9, 1930: The act provided for detail of Public Health Officers or employees to other departments or agencies to cooperate in public health activities. The act also changed the name of the advisory board for the Hygienic Laboratory to the National Advisory Council. (Public Law 106; 46 Stat. 150)

May 14, 1930: An act to authorize the establishment of a national hydraulic laboratory in the Bureau of Standards. (Public Law 219; 46 Stat. 327)

May 23, 1930: An act to provide for plant patents. (Public Law 245; 46 Stat. 376)

May 26, 1930: The Randsell Act reorganized, expanded, and redesignated the Hygienic Laboratory as the National Institutes of Health. The act authorized $750,000 for the construction of two buildings for NIH and authorized the establishment of a system of fellowships. (Public Law 71–251; 46 Stat. L. 379)

June 11, 1930: An act to provide for the modernization of the U.S. Naval Observatory at Washington, D.C. (Public Law 343; 46 Stat. 556)

June 14, 1930: A law authorized creation of a separate Bureau of Narcotics in the Treasury Department to control trading in and use of narcotic drugs for therapeutic purposes. Also, the legislation changed the name of the Narcotics Division of the Public Health Service to the Division of Mental Hygiene, and gave the Surgeon General authority to investigate the causes, treatment, and prevention of mental and nervous diseases. (Public Law 71–357; 46 Stat. L. 585)

February 20, 1931: An act to authorize the Secretary of Commerce to purchase land and to construct buildings and facilities for radio research investigations. (Public Law 700; 46 Stat. 1196)

March 4, 1931: The Director of the Census was directed to collect and publish crime statistics. (Public Law 837; 46 Stat. 1517)

May 18, 1933: Tennessee Valley Authority Act of 1933. Created a Tennessee Valley Authority (TVA) to maintain and operate a power plant at Muscle Shoals, Alabama. Other objectives of the act were to improve navigability on and provide for flood control of the Tennessee River, to improve surrounding lands and provide for agricultural and industrial development of the Tennessee Valley. (Public Law 17; 48 Stat. 58)

July 31, 1933: Science Advisory Board under the National Research Council was created by President Roosevelt by Executive Order 6238. The Executive Order authorized the Board, acting through the machinery and under the jurisdiction

of the NAS–NRC, "to appoint committees to deal with specific problems in the various departments."

June 19, 1934: Communications Act of 1934. Created a Federal Communications Commission to regulate interstate and foreign commerce communication by wire or radio. Title III provided for licenses for radio communication. The Act also gave the President war emergency power to direct communications. (Public Law 416; 48 Stat. 1064)

June 30, 1934: National Resources Board established by Executive Order 6777. The Board was later designated the National Resources Committee (Executive Order 7065, June 7, 1935) and then the National Resources Planning Board (July 1, 1939). A principal activity of the Board was the preparation of a three-volume study entitled "Research—A National Resource."

January 22, 1935: Federal Aviation Commission, appointed by the President as provided in the Air Mail Act of June 12, 1934, submitted its report and set forth broad policy on all phases of aviation and the relation of Government thereto. It recommended strengthening of commercial and civil aviation, expansion of airport facilities, and establishment of more realistic procurement practices from industry. It recommended continued study of air organization toward more effective utilization and closer interagency relationships, to include expansion of experimental and development work and its close coordination with the NACA.

April 27, 1935: The Department of Agriculture was directed to establish a Soil Conservation Service to provide for the protection of land resources against soil erosion through research, preventive measures, cooperative arrangements, and land acquisition where necessary. (Public Law 46; 49 Stat. 163)

June 29, 1935: Bankhead-Jones Act provided for the expansion of scientific, technical, economic and other research into the laws and principles underlying basic problems in agriculture. By appropriating funds for basic research, Congress recognized that its value may exceed that of research on specific problems.

Department of Agriculture implementation of the program authorized by this act led to the establishment of regional laboratories located according to problems of that area. (Public Law 182; 49 Stat. 436)

August 14, 1935: The Social Security Act was an event of major importance in the progress of public health in the United States. This act authorized health grants to the States on the principle that the most effective way to prevent the interstate spread of disease is to improve State and local public health programs. With this legislation, the Public Health Service became adviser and practical assistant to State and local services. (Public Law 74–271; 49 Stat. L. 634)

December 1935: Science Advisory Board transferred to Committee on Government Relations of NAS which was renamed the Government Relations and Science Advisory Committee. The Committee was discontinued in Oct. 1939.

May 6, 1936: Construction authorized for what later was named the David W. Taylor Model Basin, to provide a facility for use of the Navy Bureau of Construction and Repair in investigating and determining shapes and forms to be adopted for U.S. naval vessels, and including aircraft. (Public Law 568; 49 Stat. 1263)

May 20, 1936: Rural Electrification Act of 1936 established a Rural Electrification Administration to make loans to states to extend electric power to rural areas and to make and publish studies concerning the progress of the program. (Public Law 605; 49 Stat. 1363)

August 5, 1937: A law established the National Cancer Institute to conduct and support research relating to the cause, diagnosis, and treatment of cancer. The law authorized the Surgeon General to make grants-in-aid for research projects in the field of cancer, provide fellowships, train personnel, and assist the States in their efforts toward cancer prevention and control. (Public Law 75–244; 50 Stat. L. 559)

February 16, 1938: Agricultural Adjustment Act of 1938 declared it to be the policy of Congress to conserve and improve the nation's soil resources; to regulate commerce in cotton, wheat, corn, tobacco, and rice to assure a balanced flow, and to bring about "parity prices" and "parity income" for agricultural producers. The act authorized funds to establish and maintain laboratories to conduct research on the industrial utilization of agricultural products. One of four regional research laboratories thus established later became famous for its role in developing mass production of penicillin. (Public Law 430; 52 Stat. 31)

June 23, 1938: Civil Aeronautics Act of 1938 coordinated all nonmilitary aviation under a new Civil Aeronautics Authority. An Air Safety Board was established to investigate and report on accidents and make recommendations for accident prevention. (Public Law 706; 52 Stat. 973)

April 3, 1939: The Reorganization Act of 1939 transferred the Public Health Service from the U.S. Treasury Department to the Federal Security Agency. (Public Law 76–19; 53 Stat. L. 561)

July 1, 1939: Federal Security Agency created, grouping under one administration those agencies whose major purposes were to promote social and economic security, educational opportunity, and health of the citizens of the Nation; namely, Office of Education, Public Health Service, Social Security Board, U.S. Employment Service, Civilian Conservation Corps, and National Youth Administration. (Reorganization Plan I, effective this date.)

August 9, 1939: Congress authorized construction of second NACA research station at Moffett Field, Calif., which became the Ames Aeronautical Laboratory. (Public Law 361; 53 Stat. 1306)

June 26, 1940: Congress authorized construction of the third NACA laboratory near Cleveland, Ohio, which became Aircraft Engine Research Laboratory. In 1948, it was named for George W. Lewis, NACA Director of Aeronautical Research, 1924–47. (Public Law 667; 54 Stat. 599)

July 31, 1940: A joint resolution appropriating $25 million for fiscal year 1941 to the Tennessee Valley Authority for facilities needed for the national defense. (Public Resolution 95; 54 Stat. 781)

May 7, 1941: An act providing for annual inspections of coal mines by the Secretary of the Interior acting through the U.S. Bureau of Mines to assure health and safety conditions, to determine basis for expenditure of public funds toward this goal or for educational materials and to obtain information for Congress on accidents, occupational diseases and other matters for legislative action. (Public Law 49; 55 Stat. 177)

June 28, 1941: Office of Scientific Research and Development (OSRD) in the Office of Emergency Management was created by President Roosevelt by Executive Order 8807.

July 16, 1941: A joint resolution appropriating an additional sum of $40 million for the Tennessee Valley Fund for fiscal year 1942.

The resolution also amended the 3d proviso in the Military Appropriation Act for 1942 (Public Law 139) to read "*Provided further*, That with respect to the $500,000,000 provided by this Act which is not for payments under the aforesaid contract authorizations, no obligations shall be incurred for or on account of the objects specified under this head except in pursuance of said specific appropriation." (Public Law 181; 55 Stat. 597)

August 21, 1941: An act prohibiting foreign patenting of an invention made in the United States, except when licensed to do so by the Commissioner of Patents. (Public Law 239; 55 Stat. 657)

September 24, 1941: An act authorizing funds for construction of an Army Medical Library and Museum in the District of Columbia. (Public Law 256; 55 Stat. 731)

October 31, 1942: An act giving the Government power to fix royalties for the use of inventions needed in the prosecution of the war. (Public Law 768; 56 Stat. 1013)

April 16, 1943: Female physicians and surgeons in the Medical Corps of the Army and Navy were authorized by this act. Persons so appointed were commissioned in Army or the Naval Reserve. (Public Law 38; 57 Stat. 65)

July 12, 1943: A Pharmacy Corps was established in the Medical Department of the Army. (Public Law 130; 57 Stat. 430)

November 11, 1943: Public Health Service Act of 1943. Set forth the organization and structure of the Public Health Service, including provisions for its operation in time of war and the effect of the war upon commissioned officers of the corps. (Public Law 184; 57 Stat. 587) (This act was repealed by a more comprehensive act of July 1, 1944)

April 5, 1944: The Secretary of the Interior through the Bureau of Mines was authorized to construct and operate demonstration plants to produce synthetic liquid fuels from coal, oil shales, agricultural and forestry products, and other substances, for wartime needs. In this connection the Secretary of Interior was authorized to conduct laboratory research and development work, to acquire patent rights, to contract for plant construction and operations, to cooperate with other public or private agencies toward this end, and to sell

the products of the plants at cost with priority to Federal and State agencies. (Public Law 290; 58 Stat. 190)

July 1, 1944: The Public Health Service Act consolidated and revised laws pertaining to the Public Health Service and divided the Service into the Office of the Surgeon General, Bureau of Medical Services, Bureau of State Services, and the National Institute of Health. The act gave the Surgeon General broad powers to conduct and support research into the diseases and disabilities of man, authorized projects and fellowships, and made the National Cancer Institute a division of NIH. The act also empowered the Surgeon General to treat at Public Health Service medical facilities, for purposes of study, persons not otherwise eligible for such treatment. (Public Law 78–410; 58 Stat. L. 682) Under this provision, the Clinical Center was later established.

September 21, 1944: Department of Agriculture Organic Act of 1944 consolidated the department's functions with respect to eradication and control of animal and plant pests and diseases, fire control, national forest management, soil conservation, and operation of the Farm Credit Administration and the Rural Electrification Administration. (Public Law 425; 58 Stat. 734)

April 25, 1945: Supplemental appropriation passed by Congress authorized expanded research on guided missiles at NACA Langley Laboratory, including establishment of a rocket launch facility at Wallops Island, Va. (Public Law 40; 59 Stat. 82)

June 6, 1945: The Bankhead-Flannagan Act provided for expansion of county extension work. The act amended an earlier act of June 29, 1935 which provided for research into basic laws and principles relating to agriculture, for the further development of cooperative agricultural extension work and the more complete endowment and support of land-grant colleges. (Public Law 76; 59 Stat. 231)

July 3, 1946: The National Mental Health Act was designed to improve the mental health of U.S. citizens through research into the causes, diagnosis, and treatment of phychiatric disorders. It authorized the Surgeon General to support research, training, and assistance to State mental health programs. (Public Law 79–487; 60 Stat. L. 421) (The National Institute of Mental Health was established under the authority of this law on April 1, 1949.)

July 5, 1945: Dr. Vannevar Bush, Director, Office of Scientific Research and Development, submitted report, "Science, the endless frontier" to President Truman covering all aspects of the study of post-war science which President Roosevelt had requested him to make in November 1944.

A principal recommendation of the report was for the establishment of a National Research Foundation, responsible to the President and to Congress, "to develop and promote a national policy for scientific research and scientific education" and for other purposes.

July 15, 1946: Reorganization Plan No. 2, effective this date, transferred to the Federal Security Agency (the predecessor of HEW), a number of activities relating to education, health, welfare and social insurance. The Social Security Board was abolished and its functions were transferred to the Federal Security Administrator.

August 1, 1946: Atomic Energy Act of 1946 established the Atomic Energy Commission to be the exclusive owner of all facilities for the production of fissionable materials, and of all fissionable material produced. The Commission was made responsible for research and production of atomic energy for military purposes. All patents relating to fissionable materials were to be filed with the Commission.

The act also established the Joint Committee on Atomic Energy, the only joint congressional committee with substantive oversight powers. (Public Law 585; 60 Stat. 755)

August 1, 1946: Vocational Education Act of 1946 was a revision of the earlier act of June 8, 1936. Authorized annual appropriations of Federal aid funds to the States for training in agriculture, home economics, trades and industry and distributive occupations. Also appropriated an annual sum to the Office of Education for studies and investigations in the field. (Public Law 586; 60 Stat. 775)

August 1, 1946: An act to establish an Office of Naval Research in the Department of the Navy; to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security; to provide within the Department of the Navy a single office, which, by contract and otherwise, shall

be able to obtain, coordinate, and make available to all bureaus and activities of the Department of the Navy, world-wide scientific information and the necessary services for conducting specialized and imaginative research, to establish a Naval Research Advisory Committee consisting of persons preeminent in the fields of science and research, to consult with and advise the Chief of such Office in matters pertaining to research. (Public Law 588; 60 Stat. 779)

August 2, 1946: Legislative Reorganization Act of 1946 redefined the standing committees of the Senate and House of Representatives, and enumerated the jurisdictions of each committee. The act also established an enlarged and continuing separate department of the Library of Congress, the Legislative Reference Service.

August 12, 1946: National Air Museum was established under the Smithsonian Institution by act of Congress. (Public Law 722; 60 Stat. 997)

October 17, 1946: By E.O. 9791, President Truman established a Presidential Scientific Research Board under Dr. John R. Steelman, Director of War Mobilization and Reconversion, in the Executive Office of the President, to investigate and report on the entire scientific program of the Federal Government with recommendations for providing coordination and improving efficiency of Federal research and development.

April 16, 1947: Army-Navy Nurses Act. Established a permanent Nurse Corps in the Army and Navy and a Women's Medical Specialist Corps in the Army Medical Department. (Public Law 36; 61 Stat. 41)

July 7, 1947: A Commission on Organization of the Executive Branch of the Government (First Hoover Commission) was established. One of the areas which it examined and reported on was Federal research. (Public Law 162; 61 Stat. 246)

July 27, 1947: S. 526, to establish a National Science Foundation, received final approval by Congress on this date. It was vetoed by President Truman on August 6, 1947, principally because of disagreement over the administrative structure of the proposed Foundation. Congressional action on this bill culminated two years of work since the first bills to create a National Science Foundation were introduced on July 19, 1945.

July 30, 1947: A temporary Congressional Aviation Policy Board was established to survey and report on the development of a national aviation policy adequate for national defense, interstate and foreign commerce, and postal service needs. (Public Law 287; 61 Stat. 676) (The Board submitted its findings in Senate Report 949 of March 1, 1948)

August 5, 1947: Army-Navy Public Health Service Medical Officer Procurement Act of 1947. Provided additional inducements to physicians, surgeons and dentists to make a career of U.S. military, naval or public health services. (Public Law 365; 61 Stat. 776)

August 6, 1947: By act of Congress, the duties and functions of the Coast and Geodetic Survey were consolidated.

August 6, 1947: President Truman vetoed S. 526, the first bill passed by Congress to establish a National Science Foundation and an Interdepartmental Committee on Science on the grounds that the proposed organizational structure would make it impossible for him to assure proper administration.

September-October 1947: The 5-vol. Steelman report entitled "Science and public policy" was issued. With respect to Executive Office science organization, the report recommended that the President designate a member of the White House staff for scientific liaison, that the Bureau of the Budget set up a unit for reviewing Federal scientific research and development programs, and that an Interdepartmental Committee for Scientific Research be created.

December 24, 1947: Interdepartmental Committee on Scientific Research and Development established by E.O. 9912. Presidential assistant, Dr. John R. Steelman, was designated to provide liaison between the President and the committee and between the office of the President and the scientific community.

December 31, 1947: Office of Scientific Research and Development in the Executive Office of the President was terminated and remaining personnel, records, and property were transferred to the National Military Establishment. OSRD created in 1941, in the Office for Emergency Management, had under Director Vannevar Bush served as a high-level coordinating body for scientific research and medical problems related to national defense during World War II.

April 24, 1948: Secretary of Agriculture is authorized to establish research laboratories for research and study of foot-and-mouth disease or other animal

diseases which constitute a threat to the U.S. livestock industry. (Public Law 496; 62 Stat. 198)

June 16, 1948: An act authorizing the Weather Bureau to study the causes and characteristics of thunderstorms, hurricanes, cyclones and other atmospheric disturbances. (Public Law 657; 62 Stat. 470)

June 16, 1948: The National Heart Act authorized the National Heart Institute to conduct, assist, and foster research; provide training; and assist the States in the prevention, diagnosis, and treatment of heart diseases. In addition, the act changed the name of National Institute of Health to National Institutes of Health. (Public Law 80–655; 62 Stat. L. 464)

June 24, 1948: The National Dental Research Act authorized the National Institute of Dental Research to conduct, assist, and foster dental research; provide training; and cooperate with the States in the prevention and control of dental diseases. (Public Law 80–755; 62 Stat. L. 598)

August 22, 1949: The act authorized the Smithsonian Institution to continue anthropological research among the American Indians. Also authorized appropriations for maintenance of the Astrophysical Observatory, and for other expenses of the Smithsonian Institution. (Public Law 259; 63 Stat. 623)

October 25, 1949: The act authorized construction and equipment of a radio laboratory building for the National Bureau of Standards. (Public Law 366; 63 Stat. 886) Another act approved this date authorized construction of a guided-missile research laboratory building for the National Bureau of Standards. (Public Law 386; 63 Stat. 905)

October 27, 1949: The Unitary Wind Tunnel Act authorized the construction of $136 million for new NACA facilities, $10 million for wind tunnels at universities, $6 million for a wind tunnel at the David W. Taylor Model Basin, and $100 million for the establishment of the Air Force Arnold Engineering Development Center at Tullahoma, Tenn., in recognition of the fact that industry could not subsidize expensive wind tunnels for research in transonic and supersonic flight. (Public Law 415; 63 Stat. 936)

May 10, 1950: National Science Foundation Act of 1950 established a Federal agency, the National Science Foundation, for the specific purpose of promoting the progress of science in the Nation. The Foundation was directed to carry out its mission by developing a national policy for the promotion of basic research and education in the sciences. The act was the culmination of a five-year post World War II effort to assure that the United States would continue to have a science reservoir of research and trained manpower. (Public Law 81–507; 64 Stat. 149)

July 21, 1950: The National Bureau of Standards was authorized to use funds for certain enumerated activities, including laboratory and office rental space, the purchase of reprints, and subsistence and research in the Arctic region. (Public Law 618; 64 Stat. 370)

July 22, 1950: The Act of March 3, 1901 which established the National Bureau of Standards was amended by this act which in enumerating the basic authority of the Department of Commerce for its scientific functions also redescribed the functions of the Bureau. (Public Law 619; 64 Stat. 371)

August 8, 1950: The act directed the National Advisory Committee for Aeronautics to equip and operate research stations,and authorized $16.5 million to expand existing facilities. (Public Law 672; 64 Stat. 418)

August 15, 1950: The Omnibus Medical Research Act authorized the Surgeon General to establish the National Institute of Neurological Diseases and Blindness, as well as additional institutes, to conduct and support research and research training relating to other diseases and groups of diseases. (Public Law 81–692; 64 Stat. 443.) (The National Institute of Arthritis and Metabolic Diseases and the National Institute of Neurological Diseases and Blindness were established under the authority of this act on November 22, 1950. Under this same act, the National Institute of Allergy and Infectious Diseases was established on December 29, 1955, replacing the National Microbiological Institute which was originally established November 1, 1948, under authority of section 202 of the Public Health Service Act.)

September 9, 1950: This act established a clearing house for the collection and dissemination of technological, scientific, and engineering information in the Department of Commerce as a service to business and industry. (Public Law 776; 64 Stat. 823)

April 20, 1951: An 11-member Science Advisory Committee in the Office of Defense Mobilization, within the Executive Office, was established by President

Truman "to advise the President and Mobilization Director Charles E. Wilson in matters relating to scientific research and development for defense."

February 1, 1952: Invention Secrecy Act of 1951 provided for the withholding of certain patents that might be detrimental to the national security. (Public Law 256; 66 Stat. 3)

May 13, 1952: Construction of a new geomagnetic station to be operated by the Coast and Geodetic Survey was authorized.

Secretary of Commerce was authorized to engage in research in science of geomagnetism and to conduct development work to improve magnetic procedures and instruments. (Public Law 338; 66 Stat. 70)

June 23, 1952: Additional aeronautical research facilities were authorized by this act for the National Advisory Committee for Aeronautics. (Public Law 403; Stat. 153)

July 3, 1952: This act authorized the Secretary of the Interior to conduct research and development on the problem of desalination. Funds for acquiring property and facilities and contract authority were authorized. The Secretary shall coordinate activities with the Secretary of Defense where feasible. (Public Law 448; 66 Stat. 328)

July 16, 1952: Military research and development was the subject of this act which authorized the Secretaries of the 3 military departments to establish advisory committees and appoint part-time personnel necessary for research and development activities, and to make 5-year contracts, with extension rights, to carry out this program. The act also required the Secretary of each department to report on contracts entered into every six months. The objective of the act was to facilitate the performance of research and development work in the armed forces. (Public Law 557; 66 Stat. 725)

January 1, 1953: By Act of July 19, 1952, earlier acts relating to patents were revised and codified, effective this date. (66 Stat. 792)

March 9, 1953: President Eisenhower appointed Admiral Lewis L. Strauss as a Special Assistant to serve him as "liaison adviser on atomic energy matters." He occupied this post and shortly thereafter that of Chairman of the AEC until 1958.

April 11, 1953: Reorganization Plan No. 1 of 1953 creating a Department of Health, Education, and Welfare went into effect this date. By this action Cabinet representation was accorded to Government functions in health, education and welfare.

June 26, 1953: An Act redefining Federal assistance for cooperative agricultural extension work, and repealing a number of acts which amended the Smith-Lever Act of May 8, 1914. (Public Law 83; 67 Stat. 83)

July 10, 1953: A new Commission on Organization of the Executive Branch (Second Hoover Commission) was set up by this act to study and recommend regarding functions which are not necessary to Government efficiency or which compete with private enterprise. (Public Law 108; 67 Stat. 142)

August 8, 1953: By legislation approved this date, the limitation in the National Science Foundation Act of 1950 which restricted its appropriation to $15 million in any fiscal year was removed. (Public Law 88–233: 67 Stat. 488)

August 13, 1953: Created a national advisory committee to study public and private methods of weather control and modification. (Public Law 256; 67 Stat. 559)

March 17, 1954: President Eisenhower issued E.O. 10521, which clarified and defined Federal agencies' responsibilities for research and development, and specified a broader role for the NSF than that in its 1950 charter by providing that the Foundation "shall from time to time recommend to the President policies for the Federal Government which will strengthen the national scientific effort and furnish guidance toward defining the responsibilities of the Federal Government in the conduct and support of scientific research."

May 13, 1954: This act created the Saint Lawrence Seaway Development Corporation and authorized U.S. participation with Canada in development of a St. Lawrence Seaway. (Public Law 358; 68 Stat. 92)

May 27, 1954: Authorized construction of certain aeronautical research facilities by National Advisory Committee for Aeronautics to be used for research for ICBM fuel and high-speed seaplane figures. (Public Law 371; 68 Stat. 142)

July 28, 1954: Authorized research work of the Department of Agriculture to be conducted by private contracts. Amended Act of June 29, 1935 (the Bankhead-Jones Act). (Public Law 545; 68 Stat. 574)

August 26, 1954: The Supplemental Appropriations Act, 1955, appropriated $2 million to the National Science Foundation to support the U.S. International Geophysical Year program sponsored and coordinated by the National Academy of Sciences. This was the initial appropriation for the IGY program. (Public Law 663; 68 Stat. 818)

August 30, 1954: The Atomic Energy Act of 1954 to amend the Atomic Energy Act of 1946. Facilitated industrial uses of atomic energy; authorized exchange of information with friendly free governments and encouraged formation of an international atomic pool for peaceful purposes. This was the first major amendment of the Atomic Energy Act of 1946. (Public Law 83–703; 68 Stat. 919)

May 23, 1955: Still another evidence of recognition of the need to promote aeronautical research for defense purposes was this authorization to the National Advisory Committee for Aeronautics for the construction of certain research facilities. Total cost was not to exceed $13.3 million. (Public Law 44; 69 Stat. 65)

June 28, 1955: This act authorized the construction of a building for a Museum of History and Technology for the Smithsonian Institution. (Public Law 106; 69 Stat. 189)

June 29, 1955: Amended the Act of July 3, 1952 relating to research in the development and utilization of saline water by providing for cooperation with additional Federal agencies and foreign public or private agencies. Authorized total funding of $10 million for period fiscal 1953 to 1963. (Public Law 111; 69 Stat. 198)

June 30, 1955: Further International Geophysical Year funding. The Independent Offices Appropriation Act 1956, appropriated $10 million to the National Science Foundation, to remain available until June 30, 1960, for the U.S. IGY program (Public Law 112; 69 Stat. 208)

July 14, 1955: An act authorizing the Secretary of Health, Education, and Welfare and the Surgeon General of the Public Health Service, in cooperation with State and local governments and public and private agencies and institutions, to recommend research programs, to provide technical assistance and encourage cooperative action for eliminating or reducing air pollution.

July 28, 1955: The Mental Health Study Act authorized the Surgeon General to award grants to nongovernmental organizations for partial support of a nationwide study and reevaluation of the problems of mental illness. Under this act, the Joint Committee on Mental Illness and Health was awarded grant support for 3 years. (Public Law 84–182; 69 Stat. L. 381)

May 10, 1956: Executive Order 10668 amended Executive Order 2859 of May 11, 1918, which formally established the National Research Council. The new Executive order clarified Government representation on the Council.

May 19, 1956: National Science Foundation received an appropriation of $27 million to remain available until June 30, 1960, for the International Geophysical Year under the Second Supplemental Appropriations Act, 1956. (Public Law 533; 70 Stat. 167)

July 3, 1956: The National Health Survey Act authorized the Surgeon General to survey sickness and disabilities in the United States on a sampling basis. (Public Law 84–652; 70 Stat. L. 489)

July 28, 1956: The Alaska Mental Health Enabling Act provided for territorial treatment facilities to eliminate the need to transport the mentally ill outside Alaska. It also authorized Public Health Service grants to Alaska for its mental health program. (Public Law 84–830; 70 Stat. L. 709)

July 30, 1956: The Health Research Facilities Act of 1956 authorized a Public Health Service program of Federal matching grants to public and nonprofit institutions for the construction of health research facilities. (Public Law 84–835; 70 Stat. L. 717)

August 2, 1956: The Health Amendments Act of 1956 authorized the Surgeon General to assist in increasing the number of adequately trained nurses and professional public health personnel. It also authorized Public Health Service grants to support the development of improved methods of care and treatment of the mentally ill. (Public Law 84–911; 70 Stat. L. 923)

August 3, 1956: This act established a National Library of Medicine in the Public Health Service. (Public Law 941; 70 Stat. 960)

August 28, 1957: Supplemental Appropriation Act, 1958, appropriated $34,200,000 for the U.S. scientific satellite "to be derived by transfer from such annual appropriations available to the Department of Defense as may be determined by

the Secretary of Defense, to remain available until expended." (Public Law 85–170; 71 Stat. 428)

September 2, 1957; Up to $45,450,000 was authorized by this act for the construction of aeronautical research facilities and land acquisition by the National Advisory Committee for Aeronautics. (Public Law 85–253; 71 Stat. 568)

November 7, 1957: President Dwight D. Eisenhower announced the creation of the Office of Special Assistant to the President for Sicence and Technology, and appointed James R. Killian, Jr., to be his first science advisor. (Radio and television address to the Nation, this date.)

November 27, 1957: Science Advisory Committee of Office of Defense Mobilization was transferred to the Executive Office of the President, and enlarged and reconstituted, was redesignated the President's Science Advisory Committee.

The action was taken to provide a more direct relationship between the Committee, the President, and the Special Assistant for Science and Technology.

July 11, 1958: An amendment to the National Science Foundation Act of 1950 authorized and directed the Foundation "to initiate and support a program of study, research, and evaluation in the field of weather modification." (Public Law 85–510; 72 State. 353)

July 21, 1958: Home Committee on Science and Astronautics established by passage of House Resolution 580.

July 24, 1958: The Senate created a new standing Committee on Aeronautical and Space Sciences. (Senate Resolution 327)

July 29, 1958: National Aeronautics and Space Act of 1958 established the National Aeronautics and Space Administration and a National Aeronautics and Space Council and defined responsibility for space activities. In a statement issued at the signing of the law, President Eisenhower said: 'The present National Advisory Committee for Aeronautics (NACA) with its large and competent staff and well-equipped laboratories will provide the nucleus for NASA. The NACA has an established record of research performance and of cooperation with the armed services. The coordination of space exploration responsibilities with NACA's tradition aeronautical research functions is a natural evolution * * * [one which] should have an even greater impact on our future." (Public Law 85–568; 72 Stat. 426)

July 29, 1958: The National Aeronautics and Space Act of 1958 which established the National Aeronautics and Space Administration also established a 9-member advisory National Aeronautics and Space Council, consisting of the President and other named representatives.

August 1, 1958: Authorized the Department of the Interior to undertake continuing studies of effects of insecticides, herbicides, fungicides and pesticides upon fish and wildlife. (Public Law 85–582; 72 Stat. 479).

August 23, 1958: Federal Aviation Agency created with passage by Congress of the Federal Aviation Act. (Public Law 726; 72 Stat. 731) (FAA was transferred to the Department of Transportation by the act of Oct. 15, 1966 which established the Department)

September 2, 1958: National Defense Education Act of 1958. This was the first general Federal aid-to-education legislation since the Morrill Act of 1862. Major administrative responsibility for the Act was assigned to the Department of Health, Education, and Welfare. Title IX of the Act created a Science Information Service in the National Science Foundation under the direction of a Science Information Council. This latter action was evidence of congressional recognition of the science information problem and an attempt to deal with it. (Public Law 85–864; 71 Stat. 1580)

September 2, 1958: A joint resolution directing the Secretary of the Interior to contract for the construction of demonstration plants for the production of usable water from saline water. (Public Law 85–883; 72 State. 1706)

March 13, 1959: By E.O. 10807, President Eisenhower established the Federal Council for Science and Technology, consisting of his Special Assistant for Science and Technology and representatives of the major science-oriented departments and agencies, to promote interagency cooperation and coordination in the planning and management of Federal scientific and technological programs.

E.O. 10807 amended E.O. 10521 of March 17, 1954, to limit the National Science Foundation's policy advisory role to basic scientific research and education in sciences, rather than "scientific research" in general as the 1954 E.O. had specified. A new section 10 of E.O. 10807 gave the Foundation a leader-

ship role in the coordination of Federal scientific information activities of the Federal Government.

E.O. 10807 also abolished the Interdepartmental Committee on Scientific Research and Department.

September 8, 1959: An amendment to the National Science Foundation Act of 1950 clarified the Foundation's authority to support programs to strengthen the nation's scientific research potential (Public Law 86–232; 73 Stat. 467)

September 23, 1959: This act defined procedures and criteria whereby the Atomic Energy Commission may "turn over" to individual States certain defined areas of regulatory jurisdiction over atomic materials.

The act also established a Federal Radiation Council to advise the President on radiation matters. (Public Law 86–373)

April 1960: The Subcommittee on National Policy Machinery of the Senate Committee on Government Operations held a series of hearings, entitled "Science, Technology, and the Policy Process."

July 7, 1960: This law sought to encourage and stimulate the production and conservation of coal in the United States by authorizing the Secretary of the Interior to establish an Office of Coal Research and contract for research to develop better methods of mining, preparing and utilizing coal. (Public Law 86–599)

September 9, 1960: Authorized the Surgeon General to make project grants to schools of public health and schools of nursing or engineering which provide graduate or specialized training in public health for nurses or engineers, in order to strengthen and expand training in these areas. (Public Law 86–720)

April 25, 1961: An amendment to the National Aeronautics and Space Act of 1958 revised the membership and functions of the National Aeronautics and Space Council and brought the Council into the Executive Office of the President, with the Vice President as Chairman. (Public Law 87–26; 75 Stat. 46)

June 14, 1961: The Subcommittee on National Policy Machinery submitted a study entitled "Science Organization and the President's Office" to the Senate Committee on Government Operations, recommending the creation of an Office of Science and Technology within the Executive Office of the President.

September 22, 1961: The saline water conversion program was expanded and extended by this act which amended the act of July 3, 1952. Authority of the Secretary of the Interior to conduct research and development activities and to cooperate with other Federal agencies was extended in considerable detail. (Public Law 87–295; 75 Stat. 628)

September 26, 1961: A United States Arms Control and Disarmament Agency was established by this act. Section 31 of Title III set forth the range of research activities which the Director was authorized to engage in. The creation of a separate agency was evidence of the United States intention to move ahead toward agreements for reduction and control of armaments, including thermonuclear, nuclear, missile, conventional, bacteriological, chemical, and radiological weapons. (Public Law 87–297; 75 Stat. 631)

June 8, 1962: In the absence of Congressional disapproval, Reorganization Plan No. 2 of 1962, establishing the Office of Science and Technology in the Executive Office of the President, became effective.

The Plan transferred certain functions from National Science Foundation to the new OST relating to the coordination of Federal policies for the promotion of basic research and education in the sciences, and those functions with respect to the evaluation of scientific research programs of Federal agencies. (27 F.R. 5419)

August 31, 1962. Communiations Satellite Act of 1962 created a private communication satellite system to serve the needs of the United States and other countries. (Public Law 87–624; 76 Stat. 419)

October 17, 1962: This act authorized the Surgeon General to establish the National Institute of General Medical Sciences and the National Institute of Child Health and Human Development. The latter was authorized to conduct and support research and training relating to maternal health; child health; human development, in particular the special health problems of mothers and children; and the basic sciences relating to the processes of human growth and development. The former was authorized to conduct and support research in the basic medical sciences and related behavioral sciences which have significance for two or more institutes, or which are outside the general area of responsibility of any other institute. (Public Law 87–838; 76 Stat. L. 1072) (On January 30, 1963, the National Institute of Child Health and Human

Development and the National Institute of General Medical Sciences were established under this act.)

October 16-November 20, 1963: The Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics held its initial hearings, entitled "Government and Science," to identify problems in the Government-science relationship and to assign priorities for dealing with them.

December 5, 1964: National Academy of Engineering of the NAS–NRC was established with the adoption by the Council of the NAS of Articles of Organization making the new Academy a parallel organization.

July 13, 1965: Environmental Science Services Administration established with entry into force of Reorganization Plan 2 of 1965, effective this date. Transferred to the new agency were the Weather Bureau, the Coast and Geodetic Survey, and the Central Radio Laboratory of the NBS.

July 22, 1965: Water Resources Planning Act provided for comprehensive planning for water resources development to be carried out by Federal-State River Basin Commissions reporting to the President through a Cabinet level Water Resources Council. (Public Law 89–80; 79 Stat. 244)

September 14, 1965: State Technical Services Act of 1965 was an attempt to make more readily available to American business, commerce and industry the benefits of federally financed research and other research by providing a national program of incentives and support to the States who establish and maintain technical service programs to accomplish the above objective. (Public Law 89–182; 79 Stat. 679)

September 30, 1965: This act authorized the Secretary of Commerce to undertake research and development in high-speed ground transportation, to undertake demonstration projects to assess public response to improvements in intercity rail passenger service, and to embark on a national program to improve the scope and availability of transportation statistics. The act provided for Federal assistance in an area which private rail carriers could no longer handle due to loss of business because of competition from other forms of transportation. (Public Law 89–220; 79 Stat. 893)

October 2, 1965: Water Quality Act of 1965 strengthened Federal water programs by creating a new agency, the Federal Water Pollution Control Administration to administer the program under the Secretary of Health, Education, and Welfare. A new research and demonstration program was authorized relating to controlling sewage from storm sewers. Funding for ongoing research was increased as were program and construction grants. (Public Law 89–234; 79 Stat. 903)

June 17, 1966: Public Law 89–454 established a temporary National Council on Marine Resources and Engineering Development in the Executive Office of the President under the chairmanship of the Vice President to plan and develop a coordinated Federal program in marine science activities. The legislation also established a Commission on Marine Science, Engineering and Resources to make a comprehensive investigation and study of marine science and recommend an overall plan for a national oceanographic program.

The National Council on Marine Resources went out of existence June 30, 1971, following the submission of the Commission's final report.

October 15, 1966: A Department of Transportation was established by this act which brought together several Federal agencies with missions relating to automobile, rail and air travel. In fulfillment of a Congressional finding that technological advances in transportation required stimulation, the Secretary of Transportation was authorized to undertake research and development in all modes of transportation and facilities. (Public Law 89–670; 80 Stat. 931)

November 8, 1967: Membership of the Federal Council for Science and Technology was enlarged by the addition of representatives from the Department of State, the Department of Housing and Urban Development, and the Department of Transportation. (Executive Order 11381, this date.)

January 2, 1968: An act extending the time for the National Commission on Marine Science, Engineering, and Resources to render its report to January 9, 1969, and authorizing the continuation of the National Council on Marine Resources and Engineering Development until June 30, 1969. (Public Law 90–242; 81 Stat. 780)

July 11, 1968: This act authorized the Secretary of Commerce to arrange for the collection of standard reference data for the benefit of scientists and the gen-

eral public. The Act is administered by the National Bureau of Standards. (Public Law 90–396; 82 Stat. 339)

July 18, 1968: Amendments to the National Science Foundation Act of 1950 constitute the first major amendment of the enabling act, although several minor changes have preceded it. The act clarifies the administrative direction of the agency as between the Director and the National Science Board. In addition, it enables the Foundation to support applied research relevant to its mission and it emphasizes the Foundation's responsibilities to report on the status of science in the Federal Government. The act also requires the Foundation to obtain annual authorization for its funds, replacing the continuing authorization contained in the original legislation. (Public Law 90–407; 82 Stat. 360)

July 21, 1968: Aircraft Noise Abatement Act of this date amended the Federal Aviation Act to impose regulations for the abatement of aircraft noise. The Federal Aviation Administration is empowered to set aircraft noise and sonic boom standards for commercial aircraft. Aircraft will be certified for flying only if they conform to these standards. (Public Law 90–411; 82 Stat. 395)

August 9, 1968: The question whether the metric system should be adopted in the United States becomes of greater concern as more and more nations adopt it. Congress took an important step with this bill which authorized the Secretary of Commerce to study the advantages and disadvantages of increased use of the metric system in the United States and to report on the matter to Congress within 3 years (Public Law 90–472; 82 Stat. 693). A final report and 12 supporting studies were transmitted to Congress in 1971.

August 16, 1968: A National Eye Institute in the National Institutes of Health was approved with the passage of the National Eye Institute Act. The Institute will focus on curing and preventing blindness, and other eye disorders and will conduct and support research and training on the health problems and needs of the blind. It is hoped that the creation of a separate institute devoted to the problems of sight will result in significant advances in this field. (Public Law 90–489; 82 Stat. 771)

September 26, 1968: This act established a National Water Commission to review water resources problems and programs. The presidentially appointed commission is expected to submit recommendations that will aid in more efficient use of existing water supplies and suggest new ways to develop water. (Public Law 90–515; 82 Stat. 868) The final report of the Commission was submitted June 14, 1973 and the Commission went out of existence later that year.

October 18, 1968: Radiation Control for Health and Safety Act of 1968 amended the Public Health Service Act to insert safeguards to workers and consumers who make or use electronic products, to assure against "unnecessary hazardous radiation." Safety standards are to be set by the Secretary of Health, Education, and Welfare after consultation with the Commerce Department (National Bureau of Standards) and advisory committees represented by Government, industry and the general public. The legislation is significant because electronic products are manufactured and used so widely that almost the entire population of the nation can be affected by potential radiation damage. (Public Law 90–602; 82 Stat. 1173)

March 5, 1970: By E.O. 11514, responsibilities of the Council on Environmental Quality in the Executive Office of the President, which had been established by P.L. 91–190, were set forth.

July 1, 1970: By Reorganization Plan No. 2 of 1970 and E.O. 11541, July 1, 1970, the Bureau of the Budget in the Executive Office of the President was redesignated as the Office of Mangement and Budget.

Reorganization Plan No. 2 also established a Domestic Council in the Executive Office of the President. Duties of the Council, including the developing for the President of alternative proposals for reaching national domestic goals, and providing policy advice to the President on domestic issues, were spelled out in E.O. 11541.

July 1, 1971: Domestic Council New Technology effort started under William M. Magruder.

October 26, 1971: P.L. 91–510, Legislative Reorganization Act of 1970, approved this date, directed the first major Congressional reorganization since the Legislative Reorganization Act of 1946. Among the provisions of the Act were the assignment of review and analytical responsibilities to the General Accounting Office and the complementary strengthening of the Legislative Reference Service, redesignated Congressional Research Service to emphasize its research responsibilities.

December 1, 1972: Treasury Secretary George P. Shultz named Assistant to the President for Economic Affairs and Chairman of a newly-established Executive Office Council on Economic Policy.

January 3, 1973: The White House announced that Dr. Edward E. David, Jr. had resigned his positions as Presidential Science Adviser and Director, Office of Science and Technology, to return to private industry.

January 26, 1973: Reorganization Plan No. 1 of 1973 transmitted to the Congress. The plan provided for the abolishment and/or transfer out of the Executive Office of the President of the Office for Emergency Planning, the Office of Science and Technology, and the National Aeronautics and Space Council. Certain functions of the Office of Science and Technology were transferred to the Director of the National Science Foundation.

January 1973: The pro forma resignations of the President's Science Advisory Committee preceding the start of a new Presidential administration were accepted and new members were not appointed.

February 22, 1973: Subcommittee on Reorganization, Research, and International Organizations of Senate Committee on Government Operations held a hearing on Reorganization Plan No. 1 of 1973.

February 26, 1973: Legislation and Military Operations Subcommittee of House Committee on Government Operations held a hearing on Reorganization Plan No. 1 of 1973.

April 4, 1973: In H. Rept. 93–106, the House Committee on Government Operations noted that since a disapproving resolution had not been introduced, it was not required to report for or against Reorganization Plan No. 1 of 1973. However, the Committee came to the conclusion that the Plan should not be opposed, despite the problems and uncertainties regarding its operation.

April 5, 1973: Sixty-day period for Congressional disapproval on Reorganization Plan No. 1 of 1973 ended this date. Plan to go into effect July 1, 1973, as specified therein.

May 14, 1973: Dr. H. Guyford Stever, Director, National Science Foundation, appointed Acting Chairman of the Federal Council for Science and Technology.

June 29, 1973: President Nixon announced the appointment of John A. Love to be an Assistant to the President for Energy and the Director of a new Energy Policy Office to be established in the Executive Office of the President. He also announced the creation of an Energy Research and Development Council, to consist of experts in the field from outside Government, to advise the Energy Policy Office.

The President further proposed the establishment of a new Cabinet-level Department of Energy and Natural Resources and an Energy Research and Development Administration.

July 1, 1973: Reorganization Plan No. 1 of 1973 went into effect.

July 1, 1973: International scientific and technical activities formerly performed by the Office of Science and Technology were transferred to the Director of the National Science Foundation.

July 2, 1973: NSF Director Stever established a Science and Technology Policy Office and named Dr. Russell C. Drew, Director. The Office also provides staff support for the Federal Council for Science and Technology, now chaired by Dr. Stever.

July 5, 1973: House Committee on Science and Astronautics announced plans for a comprehensive inquiry into Federal policy, plans and organization for the support and utilization of science and technology.

July 10, 1973: President Nixon announced the designation of Dr. H. Guyford Stever, Director of the National Science Foundation, as Chairman of the Federal Council for Science and Technology and as Science Adviser to the President. The assignment of these responsibilities was made in a letter of July 1, 1973, from the President to Dr. Stever.

July 17–24, 1973: House Committee on Science and Astronautics held four days of hearings on Federal policy, plans and organization for science and technology, with particular reference to how Reorganization Plan No. 1 of 1973 was being implemented by the Director of the National Science Foundation.

September 10, 1973: In his capacity as Science Adviser, Dr. H. Guyford Stever held the first meeting with representatives of a number of scientific and technical societies to discuss how scientific and technical advice from this community could be brought to the attention of the Federal Government.

September 27, 1973: S. 2495, Technology Resources Survey and Applications Act, introduced by Senators Magnuson, Moss and Tunney. Referred to Committee on Aeronautical and Space Science and Committee on Commerce.

November 7, 1973: In an address to the Nation on the energy emergency, President Nixon requested Congress to act on the proposal for an Energy Research and Development Administration apart from the pending new Department of Energy and Natural Resources proposal.

December 1, 1973: AEC Chairman Dixy Lee Ray presented her findings and recommendations to the President to implement a five-year $10 billion national energy research and development program. One of the recommendations was to establish an operational Energy Research and Development Administration not later than July 1, 1974.

December 4, 1973: OMB Associate Director for Natural Resources, Science, and Energy John C. Sawhill appointed Deputy Director of the newly-created Federal Energy Office in the Executive Office of the President.

January 3, 1974: With the signing of the Supplemental Appropriations Act of 1974 (PL 93-245), a total of $4 million was approved to assist the Director, National Science Foundation to carry out responsibilities as Science Adviser. Included was $2 million to establish an Office of Energy R&D Policy and Science and Technology Policy Office, $1 million to fund grants and contracts to be awarded by the Science and Technology Policy Office, and $1 million for program development and management costs.

January 7, 1974: Former Oak Ridge National Laboratory Director Alvin M. Weinberg was appointed director of R&D policy for the Federal Energy Office in the Executive Office of the President.

January 18, 1974: OMB Director Ash appointed Frank G. Zarb of Huntington, N.Y., as Associate Director for Natural Resources, Energy and Science.

February 1, 1974: The Council of the National Academy of Sciences announced the establishment of an ad hoc committee under the chairmanship of James R. Killian Jr. to look broadly at the relationships between science and technology with a view to assuring the best use of scientific and technical judgments in the development of public policy and in planning and management of Federal research and development. A report is expected within four to six months.

February 4, 1974: The Budget of the U.S. Government for fiscal year 1975 was transmitted to the Congress. The National Science Foundation requested $1.5 million for science and technology policy research, $4.5 million for energy R&D policy research, and $250,000 for consultants' fees and staff and consultant travel for STPO and the Office of Energy R&D Policy.

April 17, 1974: Deputy Treasury Secretary and Federal Energy Office Director William E. Simon was nominated to be Secretary of the Treasury. The White House announced that Mr. Simon would not be designated Assistant to the President for Economic Affairs as was outgoing Treasury Secretary George P. Schultz. It was in this role that Dr. Schultz served as Dr. Stever's channel to the President.

April 30, 1974: William E. Simon was confirmed to be Secretary of the Treasury.

May 2, 1974: Dr. H. Guyford Stever in support of his duties as Science Advisor held the second meeting with representatives of a number of scientific and technical societies to discuss and receive input concerning the societies' actions on the energy problem; definition of and needs for a national science policy role of scientific and technical societies in providing inputs to government policy decisions; an assessment of major policy issues; and the dissemination of the results of scientific research.

May 7, 1974: Federal Energy Administration was established by P.L. 93–275 as an independent executive agency, replacing the Federal Energy Office in the Executive Office of the President.

June 16, 1974: House Committee on Science and Astronautics announced that the second phase of the committee's inquiry into Federal policy, plans, and organization for science and technology will begin on June 20, 1974, and continue intermittently through July 18.

June 20–July 18, 1974: The House Committee on Science and Astronautics held nine days of hearings on Federal policy, plans, and organization for science and technology. Twenty-six witnesses gave testimony; several other individuals submitted statements for the record.

June 26, 1974: Appearing as a witness before the House Committee on Science and Astronautics, James R. Killian, Jr. presented the findings of the ad hoc Committee on Science and Technology of the National Academy of Sciences on the general question of scientific and technical advice to the government, in-

cluding the advisory and coordinating functions previously carried out by the White House science advisory complex. The report, entitled "Science and Technology in Presidential Policymaking: A Proposal" recommended the establishment of a Council for Science and Technology as a staff office in the Executive Office of the President.

June 26, 1974: The Chairman of the House Committee on Science and Astronautics directed his staff to begin drafting legislation to improve the advisory, planning, and organizational aspects of Federal science policy.

June 27, 1974: Senators Magnuson, Moss and Tunney introduced an amendment (No. 1537) to S. 2495 which would provide for the establishment of a Council of Advisors on Science and Technology in the Executive Office of the President and the submission of an annual science and technology report,

July 10, 1974: Interim Report of the House Committee on Science and Astronautics, Federal Policy, Plans and Organization for Science and Technology, was published (House Report 93–1184, 93d Congress 2d session).

July 11, 1974: Senate Committee on Commerce and Committee on Aeronautical and Space Sciences held a joint hearing on amendment No. 1537 to S. 2495.

September 18, 1974: Senate Commerce Committee and the Committee on Aeronautical and Space Sciences reported favorably S. 2495, amended, to establish a Council of Advisors on Science and Technology in the Executive Office of the President, and an interagency Federal Coordinating Council on Science and Technology to replace the Federal Council for Science and Technology, and to direct the President to transmit an annual science and technology report to Congress. Referred to Committee on Labor and Public Welfare.

October 8, 1974: Special Subcommittee on National Science Foundation of the Senate Committee on Labor and Public Welfare held a hearing on S. 32, as amended, S. 2495, and S. 1686.

October 9, 1974: Senate Committee on Labor and Public Welfare reported favorably S. 32, with an amendment in the nature of a substitute, incorporating the text of S. 2495 as reported September 18, 1974, amending the National Science Foundation Act of 1950, and providing for State and regional science and technology programs.

October 11, 1974: S. 32 passed the Senate as reported.

October 11, 1974: President Ford signed the Energy Reorganization Act of 1974 (P.L. 93–438)

October 11, 1974: By Executive Order 11814, the Energy Resources Council authorized by P.L. 93–438 was activated, and the Secretary of the Interior was named Chairman. The Council, located in the Executive Office of the President, is charged with developing a single national energy policy and program, and performing such other functions as are assigned to it by the President.

October 15, 1974: S. 32 was referred to the House Committee on Science and Astronautics.

December 21, 1974: President Ford asked Vice President Rockefeller to study the question of whether the system of a White House science adviser should be revived, and if so, in what form, and to report to him his recommendations "in a month or so from now."

December 31, 1974: Federal Nonnuclear Energy Research and Development Act of 1974 (P.L. 93–577) set forth the duties and authorities of the Administrator of the Energy Research and Development Administration, outlined a program of Federal assistance and demonstrations, defined the patent policy for inventions developed under ERDA contracts, and provided for assistance in developing energy-related inventions.

January 15, 1975: S. 32, National Policy and Priorities for Science and Technology Act of 1975, reintroduced by Senator Kennedy et al. Referred to Committees on Labor and Public Welfare, Commerce, and Aeronautical and Space Sciences.

January 15, 1975: S. 79, to establish the United States Science and Technology Board introduced by Senator Mathias. Referred to Committee on Finance.

January 19, 1975: By Executive Order 11834, of January 15, 1975, President Ford directed the activation of the Energy Research and Development Administration and the Nuclear Regulatory Commission, effective January 19, 1975.

March 6, 1975: H.R. 4461, National Science Policy and Organization Act of 1975, introduced by Mr. Teague and Mr. Mosher. Referred jointly to Committees on Science and Technology and Government Operations.

May 22, 1975: President Ford made a decision to create a position of White House science and technology adviser with a small staff.

June 23, 1975: House Committee on Science and Technology held hearings on H.R. 4461, National Policy and Organization Act of 1975, H.R. 7830, Presidential Science and Technology Advisory Organization Act of 1975 (the Administration bill), and related bills.

July 30, 1975: H.R. 9058, a revised version of H.R. 4461, was introduced. The bill would establish a science and technology policy for the United States, provide for scientific and technological advice and assistance to the President, provide for a comprehensive survey of the Federal scientific research and information effort, amend the National Science Foundation Act of 1950, and for other purposes.

October 20, 1975: H.R. 10230, a revised version of H.R. 9058 was introduced. The two bills were the same in major respects.

November 6, 1975: H.R. 10230 debated and passed by the House with two amendments, one to strike the section providing for periodic reassessment and reorganization of the Office of Science and Technology Policy, and the other to delete the language authorizing the Director of the Office of Science and Technology Policy to appoint personnel without regard to present law governing such appointments.

APPENDIX B

Annotated List of Acronyms and Abbreviations of Organizations Frequently Appearing in Science Policy Literature with Selected List of Scientific and Technical Societies

INTRODUCTION

The purpose of this Appendix is to provide a convenient reference to frequently used acronyms and abbreviations of organizations which appear in the literature of science policy. In most cases, the organic act creating the organization, and the purpose, and illustrative activities or programs of each organization are briefly described. The list is very selective. The short identifications of agencies are merely explanatory and do not define all their purposes, activities, or programs. The subsequent amendments to the organic legislation or other additional legislation that pertains to a particular organization are usually omitted.

The appendix also contains a selected list of scientific and technical societies whose names frequently appear in the science policy literature.

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Organizations *Related to—*

AAAS—American Association for the Advancement of Science.

AAAS was founded in 1848 to further the work and cooperation of scientists, and to improve the public understanding and the effectiveness of the role of science in promoting human welfare. The AAAS is involved in improving the quality of science education, a Foreign Scientists Program, and publishing scientific information.

ACDA—Arms Control and Disarmament Agency (also USACDA) ______________ *U.S. Government*

The United States Arms Control and Disarmament Agency was established in 1961 and its Director serves as the principal adviser to the President and Secretary of State on arms control and disarmament.

The Agency is responsible for the conduct of studies and the provision of advice relating to arms control and disarmament policy formulation; the preparation for and management of U.S. participation in international negotiations in the arms control and disarmament field; the dissemination and coordination of public information in this field; and the preparation for, operation of, or, as appropriate, direction of U.S. participation in such international control systems as may become part of U.S. arms control and disarmament activities.

AEC—Atomic Energy Commission (also USAEC) __________________________ *U.S. Government*

The AEC, created by the Atomic Energy Act of 1946, was responsible for developing atomic energy technology for defense and industrial uses and for regulations to ensure safe use of nuclear processes. The Energy Reorganization Act of 1974 abolished the AEC and divided its functions between the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC).

AFSC—Air Force Systems Command___Department of the Air Force
Department of Defense

AFSC is one of the 15 major commands which together with 11 separate operating agencies represents the field organization of the U.S. Air Force. The responsibility of the Air Force Systems Command is to advance aerospace technology, adapt it into operational aerospace systems, and acquire qualitatively superior aerospace systems and material needed to accomplish the U.S. Air Force mission.

AID—Agency for International Development (also USAID)_____________________ Department of State

The Agency for International Development (AID) was established by State Department Delegation of Authority 104 to encourage and support efforts by the developing countries to meet

the fundamental needs of their people for sufficient food, good health, and employment. AID carries out development assistance programs overseas designed to promote the economic and social modernization of developing countries.

ANL—Argonne National Laboratory___Energy Research and Development Administration

This major research center's program includes fundamental and applied research and engineering development. While the basic orientation of much of the Laboratory's effort has traditionally been reactor development, there has been increasing emphasis on high-energy physics.

ARS—Agricultural Research Service___ Department of Agriculture

The ARS was established by the Secretary of Agriculture in 1953 to furnish the technology and knowledge that is necessary for the farmer to produce efficiently, conserve the environment, and meet the food and fiber needs of the country. Research is conducted in such fields as plant science, entomology, and soil sciences.

ARPA—Advanced Research Projects Agency_________ See DARPA

BIPM—International Bureau of Weights and Measures (Bureau International des Poids et Mesures).

BIPM was set up in 1875 for the establishment of international standards and of measurement scales of physical quantities. The Bureau's activities include research laboratories and consultative committees.

BNL—Brookhaven National Laboratory__ Energy Research and Development Administration

BNL is a major ERDA research center. The principal areas of research activity are: physics, chemistry, biology, nuclear technology, and medical research.

CBO—Congressional Budget Office_________________ U.S. Congress

The Congressional Budget Office was established by Public Law 93–344, the Congressional Budget and Impoundment Control Act of 1974. The functions of the Office as outlined by the Act are "to assist the Committees on the Budget of both Houses of Congress in the discharge of all matters within their jurisdiction." Specifically it should provide "(1) information with respect to the budget, appropriations bills, and other bills authorizing or providing budget authority or tax expenditures, (2) information with respect to revenues, receipts, estimated future revenues and receipts, and changing revenue conditions, and (3) such related information as the Committee may request." The Office also will provide similar information to the Committee on Ways and Means and the Committee on Finance at their request. In addition any Committee or Member of Congress can request information compiled by CBO in carrying out the above functions.

The Director of the Congressional Budget Office must submit an annual report, on or before April 1, to the Budget Committees of both Houses which should consist of a statement of the present budgetary situation plus a discussion of national budget priori-

ties. This second part of the report will include "alternative ways of allocating budget authority and budget outlays for the following fiscal year among major programs taking into account how such allocations will meet major national needs."

CEA—Council of Economic Advisers___________ Executive Office of the President

The Council of Economic Advisers was established by the Employment Act of 1946 to analyze the national economy; to advise the President on economic developments; to appraise the economic programs and policies of the government; to assist in the preparation of reports, and to recommend to the President policies for economic growth and stability.

CEQ—Council on Environmental Quality_______ Executive Office of the President

The Council on Environmental Quality was established by the National Environmental Policy Act of 1969 to formulate and recommend national policies to promote the improvement of the quality of the environment. The Council develops and recommends to the President national policies which promote environmental quality, and performs a continuing analysis of changes or trends in the national environmental quality report to the Congress.

CERN—European Organization for Nuclear Research (Organisation Europeenne pour La Recherche Nucleaire).

CERN was set up in 1953 to provide for collaboration among its members in nuclear research. The original program of this organization was to do research on high energy particles and to organize and sponsor international cooperation in nuclear research. The main facilities at CERN are particle accelerators.

CIA—Central Intelligence Agency_____________ Executive Office of the President

The Central Intelligence Agency was established under the National Security Council by the National Security Act of 1947. Under the direction of the National Security Council its functions are to advise the National Security Council concerning intelligence activities of Government departments and agencies which relate to national security; to make recommendations to NSC for the coordination of these intelligence activities; to evaluate intelligence relating to national security and provide for the appropriate dissemination of this information within the Government; and to perform such other functions related to intelligence affecting the national security as the National Security Council may request. CIA "has no police, subpena, or law enforcement powers or internal security functions."

CIEP—Council on International Economic Policy__ Executive Office of the President

CIEP was created by Presidential memorandum in January 1971 to improve the coordination of U.S. Government agencies with responsibilities in the field of foreign economic affairs and to ensure that all factors affecting international economic policy are fully considered and that policy decisions are based on realistic assessments of U.S. foreign economic interests.

CIOMS—Council for International Organisations of Medical Sciences.

CIOMS was created in 1949 to facilitate exchanges of views and scientific information in the medical sciences. It employs four principal means: symposia, international congresses, assistance with the scientific programs of its members, and cooperation with UNESCO and WHO.

CNO—Chief of Naval Operations---------- Department of the Navy Department of Defense

The Chief of Naval Operations is the senior military officer of the Department of the Navy and is the principal naval adviser to the President and the Secretary of the Navy.

The Chief of Naval Operations plans for and provides the manpower, material, facilities, and services to support the needs of the Operating Forces of the Navy; maintains water transportation services for the Department of Defense; directs the Naval Reserve; and exercises authority for matters of naval administration, including matters related to security, intelligence, discipline, naval communications, and naval operations.

COMECON (CMEA)—Council for Mutual Economic Assistance—Associated with Soviet Bloc.

COMECON was established in 1949 to arrange for the exchange of economic, scientific, and technical aid and experience among the participating countries. There has been much interest in the joint development of raw materials, and of power and fuel resources by this organization. Member nations are: Albania, Bulgaria, Cuba, Czechoslovakia, the German Democratic Republic, Hungary, Mongolia, Poland, Rumania and the Soviet Union.

COPEP—Committee on Public Engineering Policy—National Academy of Engineering.

COPEP was established to provide advice and recommendations to the Federal Government on the social impacts of technology and its implications for public policy; and, more broadly, to address questions of national policy involving or affecting technology.

COSPAR—Committee on Space Research------------------ICSU

The Committee on Space Research was founded in 1958 to further the progress of scientific investigations which are carried out with the use of rockets or rocket-propelled vehicles. COSPAR is concerned with fundamental research and is not usually involved with technological problems such as propulsion, construction of rockets, guidance and control.

The purposes of this committee are achieved through the development of space research programs by the international community of scientists working through ICSU and its associated organizations.

COSPUP—Committee on Science and Public Policy-- National Academy of Sciences.

The Committee on Science and Public Policy (COSPUP) advises the Congress and agencies of the Government, upon request,

and examines future needs of research in various scientific disciplines and the applications of science to critical national problems.

CRS—Congressional Research Service---------- Library of Congress

This service for Congress was formally chartered as the Legislative Reference Service in the Legislative Reorganization Act of 1946; its duties were expanded and its name changed by the Legislative Reorganization Act of 1970. CRS provides research, analysis, reference, and other information services to the Congress. CRS responses to Committees and Members of Congress may involve the preparation of reports, making specialists available for consultations, and assembling and collating information.

CSG—Council of State Governments.

The Council of State Governments was founded in 1925 to develop and share information on administrative management among the States and in their relations with the Federal Government. This organization issues several publications and provides staff services to many affiliated groups.

DARPA—Defense Advanced Research Project Agency-- Department of Defense.

Defense Advanced Research Projects Agency, on March 23, 1972, was made a separate agency of the Department of Defense. DARPA provides for the study and the development of advanced projects. It seeks to demonstrate the feasibility of advanced programs and then transfer them to an appropriate military service.

DCA—Defense Communications Agency--- Department of Defense

DCA was established on May 12, 1960 as an agency of the Department of Defense to ensure that the Defense Communications System will be so planned and operated as to effectively meet the long-haul, point-to-point telecommunications requirements of DOD. That is, to ensure communications between the President and the Secretary of Defense, Joint Chiefs of Staff, and other agencies; between the Secretary of Defense and military departments and specified commands, between the military departments and their major commanders and subordinate headquarters, and between the unified and specified commands and their subordinate commands. DCA also provides for systems engineering and technical supervision of technical support for the National Military Command System and performs "system planning, general systems engineering, and resource integration applicable to the totality of the Department of Defense satellite communications."

DDR&E—Directorate for Defense Research and Engineering—also ODDR&E-------------------- Department of Defense

Overall research and development policy for the DOD is made by the Director of Defense Research and Engineering (DDRE). He is assisted by a considerable technical staff, by the Defense Advanced Research Projects Agency (DARPA), the Weapons Systems Evaluation Group (WSEG), and the Defense Science Board (DSB).

DIA—Defense Intelligence Agency---------- Department of Defense

The Defense Intelligence Agency was established as an agency of the Department of Defense by DOD Directive 5105.21, August 1, 1961.

Under its Director, DIA duties include the organization, direction, management, and control of DOD intelligence resources assigned to or included within the Defense Intelligence Agency. It reviews and coordinates those DOD intelligence functions retained by or assigned to the military departments. DIA also supervises the execution of all approved plans, programs, policies, and procedures for those DOD general intelligence functions and activities for which DIA has management responsibility.

DOD—Department of Defense------------------ U.S. Government

The DOD was established as an executive department of the Government by the National Security Act Amendments of 1949. The Department of Defense was created as a part of a comprehensive program designed to provide for the security of the United States through the establishment of integrated policies and procedures for the departments, agencies, and functions of the Government concerned with national security.

DOT—Department of Transportation------------ U.S. Government

The Department of Transportation was established by the Department of Transportation Act of 1966 for the purpose of developing national transportation policies and programs conducive to the provision of fast, safe, efficient, and convenient transportation at the lowest cost consistent therewith. The Department also administers uniform time matters.

DSB—Defense Science Board------------- Department of Defense

The mission of the Defense Science Board is to advise the Secretary of Defense and the Director of Defense Research and Engineering on overall research and engineering and to provide long-range guidance in these areas to the Department of Defense.

ELDO—European Launcher Development Organization.

ELDO was established in 1962 to develop and construct space vehicle launchers and their equipment. This organization has been concerned with the following launcher vehicles: EUROPA 1, and ELDO-A.

ELDO became a part of ESRO in 1974 and thereafter became a part of the European Space Agency (ESA) when ESRO was superseded by ESA in 1975.

EPA—Environmental Protection Agency-------- U.S. Government

The Environmental Protection Agency (EPA) was established as an independent agency pursuant to Reorganization Plan 3 of 1970.

EPA was created to permit coordinated and effective governmental action to assure protection of the environment by the systematic abatement and control of pollution through a variety of research, monitoring, standard setting, and enforcement activities. EPA coordinates and supports research and anti-pollution activities.

EPA is involved in such activities as air and water quality protection, control of use of pesticides, and disposal of industrial and municipal wastes.

ERC—Energy Resources Council-- Executive Office of the President

The Energy Resources Council was established under the Energy Reorganization Act of 1974 and was expanded under Executive Order 11814. It is the responsibility of the Council to ensure communication and coordination among agencies of the Federal Government which have responsibilities for development and implementation of energy policy or for management of energy resources; to make recommendations to the President and to the Congress for measures to improve implementation of Federal energy policies or management of energy resources; and to advise the President on matters related to reorganization for energy coordination.

ERDA—Energy Research and Development Administration---------------------- U.S. Government

The Energy Reorganization Act of 1974 abolished the Atomic Energy Commission and divided its functions between ERDA and the Nuclear Regulatory Commission (NRC). ERDA is the lead agency for various energy production and conservation research and development activities on fossil fuels, solar heating and cooling, geothermal resources, nuclear energy, and alternative automotive systems. The duties of the Administrator of ERDA include: exercising central responsibility for policy planning, coordination, support, and management of R&D programs for energy sources; supporting and conducting environmental, biomedical, physical, and safety research related to the development of energy sources and utilization; developing and distributing scientific and technical information related to energy; conducting and encouraging research and development of the extraction, conversion, storage, transmission, conservation, and utilization phases of all energy sources; and increasing supply of manpower for energy R&D through assistance to education and training programs.

ESA—European Space Agency.

ESA, established at the end of May 1975, supersedes the European Space Research Organisation (ESRO) which was established in 1962 to promote and provide for collaboration among European States in space technology and research. ESA has the same functions as the old organization and includes a new dimension, an emphasis on space applications in addition to space research.

In line with this new accent on applications, three major satellites are scheduled for launching in 1977 as a part of the ESA program: METEOSAT is designed for recording and transmitting weather data; OTS, an experimental communications satellite, is designed to test systems for telephone, telex, and data traffic as well as TV relay; and MAROTS, another experimental satellite, is designed to test maritime communications.

ESC—European Space Conference.

ECS was established in 1966 to develop a coordinated European space policy and watch over its implementation.

ESRO—European Space Research Organisation.

ESRO was established in 1962 to promote and provide for collaboration among European States in space technology and

research. Some of the activities that ESRO has been concerned with are: launching of sounding rockets; putting small satellites into orbit; putting into orbit an astronomical observatory; and carrying out astronomical experiments. ESRO became a part of the European Space Agency (ESA) in 1975.

FAA—Federal Aviation Administration—Department of Transportation

Formerly the Federal Aviation Agency. FAA became a part of the Department of Transportation in 1967 as a result of the Department of Transportation Act. The Federal Administration is charged with "regulating air commerce to foster aviation safety; promoting civil aviation and a national system of airports; achieving efficient use of navigable airspace; and developing and operating a common system of air traffic control and air navigation for both civilian and military aircraft."

FAO—Food and Agriculture Organisation________United Nations

FAO was established in 1945 to improve the efficiency of the production and distribution of all food and agricultural products, to raise the levels of nutrition and standards of living of people, and to better the conditions of rural populations. Some of the activities that FAO is involved in are: the collection, analysis, and dissemination of technical and scientific information; the organization of international meetings; and the provision of technical assistance to developing countries.

FCC—Federal Communications Commission______ U.S. Government

The Federal Communications Commission was created by the Communications Act of 1934 to regulate interstate and foreign communications by wire and radio. Some illustrative areas of concern include: broadcasting, cable television, and safety and special radio services.

FCST—Federal Council for Science and Technology ______________ National Science Foundation

The Council was established by Executive Order 10807 in 1959 to promote better cooperation among Federal agencies, to facilitate resolution of common problems, to improve planning and management in science and technology, and to advise and assist the President regarding Federal programs affecting more than one agency. The Director of the National Science Foundation serves as Chairman of the FCST.

FDA—Food and Drug Administration______. Department of Health Education, and Welfare

The name "Food and Drug Administration" was first provided by the Agriculture Appropriation Act of 1931, although similar law enforcement functions had been carried on under different organizational titles since 1907.

FDA's activities are directed toward protecting the public health of the Nation. FDA is concerned with such matters as product safety, drugs, veterinary medicine, radiological health, and safety of foods.

FEA—Federal Energy Administration------------ U.S. Government

The FEA, established by Public Law 93–275, is to ensure that the supply of energy available to the United States will continue to be sufficient to meet the nation's total energy demand. FEA seeks to ensure that, in the case of energy shortages, priority needs for energy are met, and that the burden of the shortages is borne with equity. Tasks assigned to the Administrator of FEA include those to advise the President and the Congress on a comprehensive national energy policy in relation to the energy matters for which the agency has responsibility; to assess the adequacy of energy resources to meet demands in the immediate and longer range future; to promote stability in energy prices to the consumer; to develop and oversee the implementation of equitable voluntary and mandatory energy conservation programs; and to promote efficiencies in the use of energy resources.

FHWA—Federal Highway Administration—
Department of Transportation

The Federal Highway Administration became a component of DOT pursuant to the Department of Transportation Act in 1967, and is responsible for carrying out the highway transportation programs of DOT. Some of the major FHWA activities are to administer the Federal-aid highway program of financial assistance to the States for highway construction; to develop and administer programs relating to highway safety; and to exercise jurisdiction over the safety performance of commercial motor carriers engaged in interstate or foreign commerce. FHWA also coordinates wide-ranging research and development programs directed toward the problems of traffic congestion; highway safety; effective design and reduced construction and maintenance costs and the social, economic, and environmental impact of highway transportation.

FPC—Federal Power Commission---------------- U.S. Government

The FPC, originally operated under the Federal Water Power Act of 1920, regulates interstate aspects of the electric power and natural gas industries. Some of the Commission's activities include: issuing permits and licenses, and regulating rates and transactions in electric power and natural gas.

FTD—Foreign Technology Division (Wright-Patterson Air Force Base) -------------------------- Department of Defense

To prevent possible technological surprise by a potential enemy the FTD acquires, evaluates, analyzes, and disseminates foreign aerospace technology in concert with other divisions and centers. Information collected from a wide variety of sources undergoes screening and is processed in unique electronic data handling and laboratory processing equipment. Then it is analyzed by scientific and technical specialists who prepare reports, studies and technical findings and assessments of potential hostile technological or operational environs with which U.S. Air Force weapons systems must cope.

GAC—General Advisory Committee-- Energy Research and Development Administration

A statutory committee consisting of nine members appointed by the President, whose original function was to advise the U.S. Atomic Energy Commission on scientific and technical matters relating to materials, production, and research and development.

GAO—General Accounting Office------------------ U.S. Congress

The General Accounting Office was created by the Budget and Accounting Act in 1921 to assist the Congress in providing legislative control over the receipt, disbursement, and application of public funds.

The primary purpose of these audits is to make for the Congress independent determinations of the way in which Government agencies are discharging their financial responsibilities.

GARP—Global Atmospheric Research Programme-- United Nations

A global experiment to study the general circulation of the atmosphere was first suggested in 1965 in the first Report of the Committee on Atmospheric Sciences of the nongovernmental International Council of Scientific Unions (ICSU). The experiment was established the following year under the auspices of the World Meteorological Organization (WMO) and ICSU as a Global Atmospheric Research Programme.

From its formal inception to the present, GARP has received increasing support from the world community. International interest and support have intensified behind efforts to achieve the goals of GARP: to provide the improved understanding of the global circulation needed to extend the range and accuracy of weather forecasts; to understand the physical basis of climate and climate change; and to provide a firm foundation for the evolving World Weather Watch.

GSFC—Goddard Space Flight Center-- National Aeronautics and Space Administration

Goddard's program of responsibilities include scientific research in space with unmanned satellites; research and development of meteorological and communications satellites; and tracking and data acquisition operations.

HEW—Health, Education, and Welfare---------- U.S. Government

The Department of Health, Education, and Welfare was created by Reorganization Plan 1 of 1953 to administer those agencies of the Government dealing with health, education, and social security.

HSMHA—Health Services and Mental Health Administration------ Department of Health, Education, and Welfare

HSMHA was established as part of the Public Health Service in 1968 by the Secretary of HEW. HSMHA provides leadership to programs to improve general health services and mental health programs. It is responsible for development of health care and maintenance systems. HSMHA is divided into 15 major services such as maternal and child health, community health, and family planning.

IAEA—International Atomic Energy Agency ------ United Nations

The International Atomic Energy Agency was established in 1956 to encourage and assist research on the development and use of atomic energy for peaceful uses. Some of the methods by which the Agency conducts its scientific programs include: maintaining mobile laboratories; undertaking research or providing research grants to scientific institutions; coordinating research programs; working on the development of health, safety, and waste management control and regulation codes; and holding international meetings.

ICSU—International Council of Scientific Unions.

ICSU was founded in 1931 to coordinate the activities of international scientific unions in the exact and natural sciences, and to serve as a coordinating center for national scientific organizations. Through the intermediary of the national adhering organizations, ICSU enters into relationships that promote scientific research.

IDA—Institute for Defense Analyses.

IDA draws on individuals from the entire university community and from the public at large to provide "an independent and objective source of analyses, evaluations, and advice for the United States Government." Originally formed to meet the needs of the Department of Defense, IDA has expanded its interest to areas other than defense and national security. Areas of interest include communications research, international and social studies, program analysis, science and technology, and systems evaluation.

ITU—International Telecommunications Union ---- United Nations

ITU became a specialized agency under the United Nations in 1947. The purposes of ITU are (a) to maintain and extend international cooperation for improvement and rational use of telecommunication of all kinds; (b) to promote the development of technical facilities.

Its scientific objectives include the effective allocation of the radio-frequency spectrum and the adoption of standards for international telecommunications media. It also has technical assistance functions.

JCAE—Joint Committee on Atomic Energy -------- U.S. Congress

The Joint Committee on Atomic Energy was established by the Atomic Energy Act of 1946 which created the Atomic Energy Commission. The functions of the Committee are to "make continuing studies of the activities of the Atomic Energy Commission and of problems relating to the development, use, and control of atomic energy." In addition, "all bills, resolutions, and other matters in the Senate or the House of Representatives relating primarily to the Commission or to the development use, or control of atomic energy shall be referred to the Joint Committee."

JCS—Joint Chiefs of Staff --------------- Department of Defense

The Joint Chiefs of Staff are the principal military advisers of the President, the National Security Council, and the Secretary of Defense. Responsibilities of the Joint Chiefs of Staff include the preparation of strategic plans and provision for the strategic direction of the Armed Forces; preparation of integrated plans

for military mobilization and integrated logistic plans; recommending to the Secretary of Defense the establishment and force structure of unified and specified commands; review of major personnel, materiel, and logistic requirements of the Armed Forces; providing the Secretary of Defense with statements of military requirements and strategic guidance for use in the development of budgets, foreign military aid programs, industrial mobilization plans, and programs of scientific research and development; and providing the U.S. representation on the Military Staff Committee of the United Nations.

JPL—Jet Propulsion Laboratory -------- National Aeronautics and Space Administration

Operated under contract by the California Institute of Technology, the Jet Propulsion Laboratory is concerned with deep space, lunar, and interplanetary scientific exploration, development of unmanned lunar and interplanetary spacecraft, and the operation of related tracking and data acquisition systems.

KAPL—Knolls Atomic Power Laboratory ---- Energy Research and Development Administration

KAPL, established in 1946, is a power reactor development center, principally for Naval reactor programs.

LASL—Los Alamos Scientific Laboratory ----- Energy Research and Development Administration

LASL was established in 1942 as a research center to engage in fundamental and applied research in weapons; later, other areas like controlled fusion, reactor development, nuclear rocket propulsion, and direct energy conversion were added.

MARAD—Maritime Administration ---- Department of Commerce

The Maritime Administration was established by Reorganization Plan 21 of 1950, effective May 24, 1950. MARAD administers programs to aid in the development, promotion, and operation of the U.S. merchant marine. It provides financing guarantees for the construction, reconstruction, and reconditioning of ships; conducts programs to develop ports, facilities, and intermodal transportation systems; and promotes domestic shipping. MARAD also conducts research and development activities to improve the efficiency and economy of the merchant marine.

NAE—National Academy of Engineering.

The National Academy of Engineering was established on December 5, 1964, by the Council of the National Academy of Sciences, under the authority of its Act of Incorporation. NAE shares in the objectives and responsibilities of the NAS. It sponsors engineering programs aimed at meeting national needs, encouraging engineering research, and advising the Federal Government upon request in matters of engineering.

NAS—National Academy of Sciences.

The NAS was established by an act of Congress in 1863 with the purpose of the furtherance of science and its use for the general

welfare. Although not a governmental agency, the Academy has long enjoyed close relations with the Federal Government. Its congressional charter of 1863 specifies that ". . . the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art . . ."

NASA—National Aeronautics
and Space Administration............ U.S. Government

NASA was established by the National Aeronautics and Space Act of 1958. Three principal functions of NASA are: to conduct research on flight within and outside the earth's atmosphere; to do research on aeronautical and space vehicles; and to conduct activities required for the exploration of space. Some of the activities of NASA are: the conduct of manned and unmanned space flights, and the maintenance of research and flight centers.

NASC—National Aeronautics
and Space Council.................. Executive Office of the President

The National Aeronautics and Space Council was established by the National Aeronautics and Space Act of 1958. The functions of the Council are to advise and assist the President regarding policies, plans, and programs; to fix the responsibilities of the United States agencies engaged in aeronautical and space activities and to develop a comprehensive program of such activities. Reorganization Plan No. 1 of 1973 abolished NASC.

NASULGC—National Association of State Universities and Land-Grant Colleges.

The Association serves to bring the collective strength of its members to bear on pressing educational issues; it focuses public attention on research contributions that State universities and land-grant colleges have made. The activities of NASULGC include: commissions, publications, and councils.

NATO—North Atlantic Treaty Organization.

NATO was established in 1949 to cordinate the collective defense of its fifteen member nations. The scientific programs of NATO are directed toward promoting scientific and technical cooperation and toward contributing to the security of the area by increasing the scientific potential of its members. Some of the methods employed by NATO to accomplish these goals are: research grants, advisory expert panels, and demonstrations of the applications of research.

NBS—National Bureau of Standards.... Department of Commerce

The National Bureau of Standards (NBS) was created by an act of Congress in 1901 to improve the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: a basis for the Nation's physical measurement system; scientific and technological services for industry and government; a technical basis for equity in trade; technical services to promote public safety; and technical information services.

NEA—Nuclear Energy Agency-------- Organisation for Economic Cooperation and Development

NEA was the new name assigned to the European Nuclear Energy Agency (ENEA) when this organization accepted Japan into its membership in 1972. NEA was set up to develop nuclear collaboration for peaceful uses among its members. The basic program of this organization is to promote the formation of joint undertakings, to formulate uniform legislation relating to nuclear energy, to cordinate research training, and to assess the role of nuclear energy in the future energy requirements of Europe.

NIH—National Institutes of Health-------- Department of Health, Education, and Welfare

The National Institutes of Health (NIH) was established as an agency within the Public Health Service by the Secretary of HEW in 1968. The National Institutes of Health programs are designed to improve the health of the people of the United States. The NIH conducts and supports research in the causes, prevention, and cure of diseases of man; administers programs to meet the Nation's health manpower requirements; directs programs for the collection, dissemination, and exchange of information in medicine and health; and administers Federal standards and licensing activities for biological products sold in interstate commerce.

NIMH—National Institute of Mental Health------------------- Department of Health, Education, and Welfare

The Institute provides for the improvement of mental health through the conduct and support of programs for the discovery and demonstration of new knowledge, and the inauguration, demonstration, and support of services to promote and sustain mental health, prevent mental illness, and treat and rehabilitate mentally ill persons. It also conducts and supports programs directed at such problems as alcoholism, narcotic addiction, drug abuse, suicide, crime, and problems of metropolitan areas.

NOAA—National Oceanic and Atmospheric Administration---------------- Department of Commerce

NOAA was formed on October 3, 1970 by Reorganization Plan 4 of 1970. Some of its missions are to study the global oceans; to assess, manage, use, and conserve the sea's resources; to study the physical environment; and to warn against impending environmental hazards. Some of its principal parts are: the National Weather Service, National Ocean Survey, and the Environmental Data Service.

NRC—National Research Council------- National Academy of Sciences and National Academy of Engineering

The Research Council was organized by the Academy in 1919, in response to a request from President Wilson, and operates in accordance with Executive Order 2859 of May 11, 1918, as amended by Executive Order 10668 of May 10, 1956. The National Re-

search Council (NRC) was organized by the NAS to facilitate the participation of a broader representation of scientists and technologists in carrying out its objectives. The NRC has become, in effect, the principal operating agency for both the NAE and the NAS. The purpose of the Council is to stimulate research in the mathematical, physical, and biological sciences, and the application of these sciences with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.

NRC—Nuclear Regulatory Commission____________U.S. Government

The Nuclear Regulatory Commission, established by the Energy Reorganization Act of 1974, was given all of the regulatory and licensing authority and functions of the former U.S. Atomic Energy Commission. The major organizational components of the Commission are the Office of Nuclear Reactor Regulation, the Office of Nuclear Materials Safety and Safeguards, and the Office of Nuclear Regulatory Research.

NSA/CSS—National Security Agency/
Central Security Agency_____ Department of Defense

The National Security Agency was established by Presidential directive in 1952 as a separate agency within the Department of Defense. In 1972 the Central Security Service was established, in accordance with a Presidential memorandum, to provide a more effective cryptologic organization within DOD. The Director of NSA is the Chief of the Central Security Service.

The National Security Agency/Central Security Service "provides centralized coordination and direction for certain very highly classified functions of the Government vital to the national security." Its assigned responsibilities include "prescribing certain security principles, doctrines, and procedures for the U.S. Government; organizing, operating, and managing certain activities and facilities for the production of intelligence information; organizing and coordinating the research and engineering activities of the U.S. Government which are in support of the Agency's assigned functions; and regulating certain communication in support of Agency missions."

NSB—National Science Board_________National Science Foundation

The National Science Board consists of 24 members, each appointed by the President, with the advice and consent of the Senate. The Board's purpose is to establish policy for the National Science Foundation; more recently the Board has concerned itself with issues of national science policy. The Board reviews and approves all new programs to be launched by the National Science Foundation as well as any major changes in ongoing programs and reviews the formulation of the Foundation's annual budget requests.

NSF—National Science Foundation_______________U.S. Government

The National Science Foundation was established by the National Science Foundation Act of 1950, as amended, and was given additional authority by the National Defense Education Act of 1958. More recently, Reorganization Plan No. 1 of 1973, effective July 1, 1973, transferred to the Director of NSF the

functions of the Office of Science and Technology which was abolished by the reorganization plan.

The purposes of the National Science Foundation are to increase the Nation's base of scientific knowledge and strengthen its ability to conduct scientific research; encourage research in areas that can lead to improvements in economic growth, energy supply and use, productivity, and environmental quality; promote international cooperation through science; and develop and help implement science education programs that can better prepare the Nation to meet future challenges.

NTIS—National Technical Information Service ______________________ Department of Commerce

NTIS was established in 1970 by the Secretary of Commerce by Department Organization Order 30-7A to improve public access to data files and scientific and technical reports produced by Federal agencies and their contractors.

It is the central point in the United States for the public sale of Government-funded research and development reports and other analyses.

The agency coordinates the publishing and technical inquiry functions of various Information Analysis Centers in the United States.

NTSB—National Transportation Safety Board____________ Department of Transportation

NTSB was created by the Department of Transportation Act of 1966 to function independently of the Secretary of Transportation and other offices and officers of the Department. NTSB activities fall into three major categories: aviation accident cause determination and safety promotion; surface transportation accident cause determination and safety promotion; and reviews on appeal of the denial of any certificate or license by the Secretary or Administrator of the Department of Transportation.

OAS—Organization of American States.

OAS was established in 1948 with the dual purpose of strengthening peace and security, and promoting the economic, social and cultural development of its members. To promote scientific as well as economic and social progress, OAS provides technical, educational and training assistance. It coordinates cooperative efforts among its member nations, and stimulates interest in research and training fellowships. OAS also coordinates its activities with the technical assistance programs of the U.S. and the U.N.

OECD—Organisation for Economic Cooperation and Development

OECD came into existence in 1961 to stimulate cooperation between member countries for economic growth, expanded world trade, and coordinated aid to less developed areas. In the scientific and technological fields the organization encourages research, promotes the development of resources, and promotes training. OECD has been involved in promoting the development and coordination of national science policies, in promoting international research, and in assisting with the scientific and educational problems of developing countries.

OEO—Office of Economic
Opportunity----------- Executive Office of the President

The Office of Economic Opportunity was established by the Economic Opportunity Act of 1964 to strengthen, supplement, and coordinate efforts to further the policy of the United States to eliminate or mitigate poverty. Most OEO programs have been transferred to the newly created Community Services Administration.

OEP—Office of Energy R. & D.
Policy--------------------- National Science Foundation

The Office of Energy R. & D. Policy was set up within NSF to support the Director in his role as science adviser by providing an independent source of advice and analysis on energy programs, research and development, and policies. Specific program objectives of the OEP include: to provide analysis of issues and programs related to energy R. & D.; to develop, support, and supply the Executive Office of the President with a framework with which systematically to evaluate energy R. & D. programs; to provide independent assessment of environmental, health, and safety standards; and to determine ways in which universities and other research organizations can make their most effective contribution to energy R. & D. from a research and manpower perspective.

OES—Bureau of Oceans and International Environmetal and
Scientific Affairs-------------------- Department of State

OES, created by Public Law 93–126, has responsibilities in international science and technology including space, environment, weather, oceans, atmosphere, fisheries, energy, wildlife, conservation, health, and population. The Bureau is to develop comprehensive and coherent U.S. policies on international science and technology issues and to advise the Secretary of State on these issues as they relate to the formulation and implementation of foreign policy. The Bureau is responsible for the analysis and evaluation of relevant policies and programs of international agencies and bilateral activities to ensure their compatibility with U.S. objectives and for developing substantive positions and strategies for dealing with these agencies and activities.

OMB—Office of Management and Budget-------- Executive Office of the President

The Office of Management and Budget was established by the Reorganization Plan 2 of 1970 to aid the President in bringing about more efficient and economical conduct of Government service; to assist the President in the preparation of the budget and the formulation of the fiscal program of the Government; and to supervise and control the administration of the budget.

ONR—Office of Naval Research------------ Department of Defense

The Office of Naval Research was established by act of Congress, 1946.

ONR plans and coordinates research programs: advises on findings and trends in research and development and disseminates such information; administers activities within or on behalf of the

Navy relating to patent and copyright function; and executes contracts for the conducting of research.

ORNL—Oak Ridge National Laboratory (Chet Holifield National Laboratory) ____________ Energy Research and Development Administration

ORNL is a major U.S. Atomic Energy Commission research center. The fields of activity with which ORNL is most closely identified include: reactor development, chemical technology, controlled fusion, raidoisotopes, and basic research. ORNL was renamed the Chet Holifield National Laboratory with the passage of P.L. 93–616.

OSHA—Occupational Safety and Health Administration—Department of Labor.

OSHA was established as a result of the Occupational Safety and Health Act of 1970 to develop and promulgate occupational safety and health standards; to develop and issue regulations; to conduct investigations and inspections to determine the status of compliance with safety and health standards and regulations; and to issue citations and propose penalties for noncompliance with safety and health standards and regulations.

OST—Office of Science and Technology _________ Executive Office of the President

The Office of Science and Technology was created by the Reorganization Plan 2 of 1962.

The Director of the Office of Science and Technology provides advice and assistance to the President with respect to developing policies and evaluating and coordinating programs to assure that science and technology are used most effectively in the interests of national security and general welfare.

This assignment is accomplished in four main ways:

1. Evaluation of major policies, plans, and programs of science and technology of the various agencies of the Federal Government;

2. Assessment of selected scientific and technical developments and programs;

3. Review, integration, and coordination of major Federal activities in science and technology; and

4. Assuring that close relations exist with the Nation's scientific and engineering communities.

Reorganization Plan No. 1 of 1973 abolished OST and transferred its functions to the Director of the National Science Foundation.

OTA—Office of Technology Assessment ____________ U.S. Congress

OTA was created by Public Law 92–484 in 1972 to provide early indications on the probable impacts of the application of technology. It is instructed to identify alternative technological methods of implementing programs and present findings of completed analyses to the appropriate legislative authorities.

PAHO—Pan American Health Organization ____ Organization of American States

PAHO was organized in 1958 on the foundations of other international organizations that had functioned from 1902 on. The

purposes of this organization are to coordinate and to promote the efforts of the countries of the Western Hemisphere to lengthen life, combat disease, and improve the physical and mental health of the people.

The activities of PAHO related to sicence might be grouped into the following categories: development and improvement of health services, including assistance in planning and operation of special health projects; the eradication and control of communicable diseases; collection and dissemination of epidemiological information and health research; improvement of food, drug, and biologics control; and education and training assistance programs.

PHS—Public Health Service------------ Department of Health, Education, and Welfare

The Public Health Service Act of July 1, 1944 consolidated and revised all existing legislation relating to the Public Health Service. Since then the responsibilities of the Service have been broadened and extended many times. The major functions of the Public Health Service are to assist States and communities with the development of local health resources; to assist with improvement of the delivery of health services to all Americans; to conduct and support research in the medical and related sciences and to disseminate scientific information; and to protect against the use of impure and unsafe foods, drugs, cosmetics, and other potential hazards.

The Service consists of six operating agencies, with the Assistant Secretary for Health having direct authority over each. The agencies are the Alcohol, Drug Abuse, and Mental Health Administration; the Center for Disease Control; the Food and Drug Administration; the Health Resources Administration; the Health Services Administration; and the National Institutes of Health.

RAE—Royal Aircraft Establishment----- U.K. Ministry of Defense

The Royal Aircraft Establishment, founded in 1918, gives technical advice on aircraft and collaborates with industry in developing flying equipment. Research programs are discussed and agreed upon with the aerospace industry through joint research committees. The establishment's current activities include supersonics, vertical takeoff; rocketry and guided missiles, automatic control and space science.

SEATO—Southeast Asia Treaty Organization.

SEATO was created in 1954 with the basic provisions that member countries are to strengthen their free institutions, and to cooperate in the further development of economic measures, including technical assistance. SEATO's activities include the furnishing of assistance in the form of medical research laboratories.

SIE—Science Information Exchange------ Smithsonian Institution

The mission of SIE is to assist the planning and management of research activities supported by Government and non-Government institutions by promoting the exchange of information that concerns current research in the prepublication stage. It helps program directors and administrators to avoid unwarranted duplication and to determine the most advantageous distribution

of research funds. It informs individual investigators about others currently working on problems in their special fields.

SIPRI—Stockholm International Peace Research Institute.

SIPRI was set up in 1966 by the Swedish Parliament as a foundation to study problems of peace and conflict with particular attention to the areas of disarmament and arms regulations. Some of the projects of past concern are: "Arms Trade With the Third World" and the "SIPRI Yearbook of World Armaments and Disarmament."

SPR—Science Policy Research Division........ Library of Congress

SPR is a division of the CRS which handles inquiries on such subjects as: science policy, aviation and space technology, biological and medical issues, behavioral sciences, earth sciences, and other science and technology issues.

STPO—Science and Technology Policy Office...... National Science Foundation

The office was established by the Director of the National Science Foundation to provide staff support for his responsibilities as Science Adviser and Chairman of the Federal Council for Science and Technology. STPO is involved in an array of Federal research and development programs and emerging problem areas including domestic technology transfer, social research and development, the national space program, food and nutrition, minerals, and materials.

UMTA—Urban Mass Transportation Administration .... Department of Transportation

UMTA operates under the authority of the Urban Mass Transportation Act of 1964 and became a component of the Department of Transportation in 1968. The broad mission of the Administration is to assist in the development of improved mass transportation facilities, equipment, techniques, and methods; encourage the planning and establishment of area-wide urban mass transportation systems; and provide assistance to State and local governments in financing such systems.

The Urban Mass Transportation Administration conducts research, development, and demonstration programs in such areas as bus transit, urban rail transit, new systems of urban mass transportation, systems analysis, transit planning research, and service development (services designed to ease transportation problems of the disadvantaged).

UNESCO—United Nations Educational, Scientific, and Cultural Organization.......... United Nations

UNESCO was founded in 1945 as a U.N. satellite organization to encourage international cooperation in education, science, and culture. To attain this purpose, UNESCO advances the mutual knowledge and understanding of peoples and encourages interna-

tional cooperation in all branches of intellectual activity. Science is a major part of the program. UNESCO coordinates research programs, aids nongovernmental international scientific organizations, and supports joint basic research programs.

UNITAR—United Nations Institute for Training and Research ---------------------- United Nations

UNITAR was founded in 1963 for the purpose of enhancing the effectiveness of the United Nations in achieving its major objectives. This task is accomplished primarily by providing training, by conducting research, by maintaining peace and security, and by promoting economic and social development.

USAEC—United States Atomic Energy Commission ---------------------- U.S. Government (see AEC)

The AEC has been abolished and its functions divided between ERDA and the Nuclear Regulatory Commission (NRC).

USAID—United States Agency for International Development------ Department of State (see AID)

USIA—United States Information Agency-------- U.S. Government

The United States Information Agency was established as an independent agency of the executive branch of the Government by Reorganization Plan 8 on August 1, 1953. USIA seeks to promote a better understanding of the United States in other countries by providing for the dissemination abroad of information about the United States, its people, culture, and policies. Among the means used to accomplish this purpose are radio broadcasting, motion pictures, television, exhibits, personal contact, seminars, information centers, English-language instructions, and book translation and distribution.

WHO—World Health Organization---------------United Nations

WHO became a specialized agency of the United Nations in 1948. It was created with the objective of attaining for all people the highest possible level of health. Some of the means WHO uses to carry out its objectives are: assisting governments in strengthening health services, furnishing technical assistance, advancing work to eradicate epidemic, endemic, and other types of disease, and promoting cooperation among groups which contribute to the advancement of health.

WMO—World Meteorological Organisation-------- United Nations

WMO, responsible for promoting international cooperation in weather observation, came into being in 1950. Two major endeavors of the WMO have been to build up a worldwide network of stations for obtaining and transmitting meteorological data and to promote cooperation among national meteorological services.

Selected List of Scientific and Technical Societies

AAS	American Astronautical Society.
AAS	American Astronomical Society.
ACS	American Ceramic Society.
ACS	American Chemical Society.
AIAA	American Institute of Aeronautics and Astronautics.
AIBS	American Institute of Biological Sciences.
AICHE	American Institute of Chemical Engineers.
AIME	American Institute of Mining, Metallurgical and Petroleum Engineers.
AIP	American Institute of Physics.
ANSI	American National Standards Institute.
APS	American Physical Society.
APS	American Polar Society.
ASA	Acoustical Society of America.
ASHRAE	American Society of Heating, Refrigerating and Airconditioning Engineers.
ASM	American Society for Metals.
ASME	American Society of Mechanical Engineers.
ASTM	American Society for Testing and Materials.
EJC	Engineers Joint Council.
FAS	Federation of American Scientists.
FMS	Federation of Materials Societies.
IEEE	Institute of Electrical and Electronics Engineers.
ISTA	International Society for Technology Assessment.
NACE	National Association of Corrosion Engineers.
ORSA	Operations Research Society of America.
OSA	Optical Society of America.
WFS	World Future Society.

APPENDIX C

Selected Bibliography of Glossaries and Related Sources of Science and Science Policy Terms

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